P NT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
P201-0084PCT		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/JP 01/03398	20/04/2001	28/04/2000
Applicant		
MAZDA MOTOR CORPORATION et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

[X] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PC[redacted]P 01/03398

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B23K20/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 1 385 473 A (LUC PENELOPE JANE VESEY) 26 February 1975 (1975-02-26) page 1, line 10 - line 13 page 1, line 32 - line 51 page 1, line 91 -page 2, line 4 page 5, line 55 - line 82 figures 1,2	1,2,4,6, 7,10 5,8
X Y	US 4 144 110 A (LUC JANE) 13 March 1979 (1979-03-13) column 1, line 6 - line 19 column 13, line 47 - line 55 column 14, line 11 - line 39 column 15, line 67 -column 16, line 22	1,2,10 5,8

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2001	25/06/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Haegeman, M

Form PCT/ISA/210 (second sheet) (July 1992)

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
OHTSUKA, Yasunori
7th FL. shuwa kioicho park bldg.3-6
kioicho
CHIYODA-KU , TOKYO 102-0094
JAPAN

RECEIVED
JUN. 26. 2001
OHTSUKA PAT

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference P201-0084PCT	Date of mailing *(day/month/year)* 25/06/2001
International application No. PCT/JP 01/03398	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
Applicant MAZDA MOTOR CORPORATION et al.	International filing date *(day/month/year)* 20/04/2001

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Donna-Marie Burns

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PC[redacted] 01/03398

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1385473 A	26-02-1975	CA 933740 A	18-09-1973
		CH 555723 A	15-11-1974
		DE 2210855 A	14-09-1972
		FR 2128733 A	20-10-1972
		JP 60033587 B	03-08-1985
		NL 7203013 A,B,	12-09-1972
		SE 411857 B	11-02-1980
		US 3831262 A	27-08-1974
US 4144110 A	13-03-1979	DE 2102020 A	21-09-1972
		FR 2128169 A	20-10-1972
		GB 1080442 A	23-08-1967
		NL 7103140 A	12-09-1972
		AT 304060 B	15-11-1972
		DE 1571045 A	22-10-1970
		FR 1584952 A	09-01-1970
		US 3831262 A	27-08-1974
		CH 460598 A	31-07-1968
		CH 528989 A	15-10-1972
		NO 127353 B	12-06-1973
		SE 338850 B	20-09-1971
DE 19746812 A	29-04-1999	NONE	
DE 19731638 A	28-01-1999	NONE	
EP 0893189 A	27-01-1999	JP 3070735 B	31-07-2000
		JP 11090655 A	06-04-1999
		JP 11314177 A	16-11-1999
		JP 11285863 A	19-10-1999
		JP 11314178 A	16-11-1999
		JP 11320131 A	24-11-1999
		JP 11285864 A	19-10-1999
		JP 11314179 A	16-11-1999
		JP 11314180 A	16-11-1999
		JP 11285865 A	19-10-1999
		JP 11314169 A	16-11-1999
		JP 11285866 A	19-10-1999
		JP 2000263251 A	26-09-2000
		JP 2000263252 A	26-09-2000
		JP 2000263253 A	26-09-2000
		JP 2000263254 A	26-09-2000
		US 6050474 A	18-04-2000
		US 6237829 B	29-05-2001

INTERNATIONAL SEARCH REPORT

International Application No
PCT 01/03398

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 197 46 812 A (HENTSCHEL HOLGER DIPL ING ;SCHAAF ANDREAS DIPL ING (DE); SUTHOFF B) 29 April 1999 (1999-04-29) the whole document	1,6,10
X	DE 197 31 638 A (SCHAAF ANDREAS) 28 January 1999 (1999-01-28) column 1, line 36 - line 45 column 2, line 26 - line 31 claims; figures	1,9,10
X	EP 0 893 189 A (HITACHI LTD) 27 January 1999 (1999-01-27) figures 8,18 column 10, line 30 - line 46 column 12, line 20 -column 13, line 5	1,9,10

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

PCT REQUEST

P201-0084PCT

Original (for SUBMISSION) - printed on 20.04.2001 10:57:42 AM

0	For receiving Office use only	
0-1	International Application No.	
0-2	International Filing Date	PCT 20.4.01 受領印
0-3	Name of receiving Office and "PCT International Application"	
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.91 (updated 01.01.2001)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Japanese Patent Office (RO/JP)
0-7	Applicant's or agent's file reference	P201-0084PCT
I	Title of Invention	METHOD OF PROCESSING METAL MEMBERS
II	Applicant	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	MAZDA MOTOR CORPORATION
II-5	Address:	3-1, Shinchi, Fuchu-cho Aki-gun, Hiroshima 735-0028 Japan
II-6	State of nationality	JP
II-7	State of residence	JP
II-8	Telephone No.	082-287-4275
II-9	Facsimile No.	082-287-5119
III-1	Applicant and/or Inventor	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
III-1-4	Name (LAST, First)	GENDOH, Toshiyuki
III-1-5	Address:	c/o MAZDA MOTOR CORPORATION 3-1, Shinchi, Fuchu-cho Aki-gun, Hiroshima 735-0028 Japan
III-1-6	State of nationality	JP
III-1-7	State of residence	JP

PCT REQUEST

Original (for SUBMISSION) - printed on 20.04.2001 10:57:42 AM

P201-0084PCT

III-2	**Applicant and/or Inventor**	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	NOMURA, Seiji
III-2-5	Address:	c/o MAZDA MOTOR CORPORATION 3-1, Shinchi, Fuchu-cho Aki-gun, Hiroshima 735-0028 Japan
III-2-6	State of nationality	JP
III-2-7	State of residence	JP
IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	OHTSUKA, Yasunori
IV-1-2	Address:	7th FL. SHUWA KIOICHO PARK BLDG., 3-6, KIOICHO CHIYODA-KU, Tokyo 102-0094 Japan
IV-1-3	Telephone No.	03-5276-3241
IV-1-4	Facsimile No.	03-5276-3242
IV-1-5	e-mail	opt@patest.co.jp
V	**Designation of States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	EP: DE ES FR GB IT and any other State which is a Contracting State of the European Patent Convention and of the PCT (except AT BE CH&LI CY DK FI GR IE LU MC NL PT SE TR)
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	CN KR US
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	**Exclusion(s) from precautionary designations**	NONE

PCT REQUEST

P201-0084PCT

Original (for **SUBMISSION**) - printed on 20.04.2001 10:57:42 AM

VI-1	**Priority claim of earlier national application**		
VI-1-1	Filing date	28 April 2000 (28.04.2000)	
VI-1-2	Number	Patent Application 2000-130039	
VI-1-3	Country	JP	
VI-2	**Priority document request**		
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)	
VIII	**Check list**	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	32	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	EZABST00.TXT
VIII-5	Drawings	38	-
VIII-7	TOTAL	78	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-9	Separate signed power of attorney	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-17	Other (specified):	Revenue stamps of transmittal fee for receiving office	-
VIII-17	Other (specified):	Submission of certificate of payment for search fee	-
VIII-17	Other (specified):	Submission of certificate of payment of international fee	-
VIII-18	**Figure of the drawings which should accompany the abstract**	1	
VIII-19	**Language of filing of the International application**	English	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name (LAST, First)	OHTSUKA, Yasunori	

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported International application**	

PCT REQUEST

Original (for **SUBMISSION**) - printed on 20.04.2001 10:57:42 AM

10-2	**Drawings:**	
10-2-1	Received	
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	**ISA/EP**
10-6	**Transmittal of search copy delayed until search fee is paid**	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	**Date of receipt of the record copy by the International Bureau**	

PCT (ANNEX - FEE CALCULATION SHEET)

Original (for **SUBMISSION**) - printed on 20.04.2001 10:57:42 AM

P201-0084PCT

(This sheet is not part of and does not count as a sheet of the international application)

0	**For receiving Office use only**	
0-1	International Application No.	
0-2	Date stamp of the receiving Office	

0-4	**Form - PCT/RO/101 (Annex)** **PCT Fee Calculation Sheet**	
0-4-1	Prepared using	PCT-EASY Version 2.91 (updated 01.01.2001)
0-9	**Applicant's or agent's file reference**	P201-0084PCT
2	**Applicant**	MAZDA MOTOR CORPORATION, et al.

12	**Calculation of prescribed fees**		fee amount/multiplier	total amounts (JPY)	
12-1	Transmittal fee	T	⇨	18,000	
12-2	Search fee	S	⇨	103,000	
12-3	International fee				
	Basic fee				
	(first 30 sheets)	b1	46,200		
12-4	Remaining sheets		48		
12-5	Additional amount	(X)	1,100		
12-6	Total additional amount	b2	52,800		
12-7	b1 + b2 =	B	99,000		
12-8	Designation fees				
	Number of designations contained in international application		4		
12-9	Number of designation fees payable (maximum 6)		4		
12-10	Amount of designation fee	(X)	10,000		
12-11	Total designation fees	D	40,000		
12-12	PCT-EASY fee reduction	R	-14,000		
12-13	Total International fee (B+D-R)	I	⇨	125,000	
12-14	Fee for priority document				
	Number of priority documents requested		1		
12-15	Fee per document	(X)	1,400		
12-16	Total priority document fee	P	⇨	1,400	
12-17	**TOTAL FEES PAYABLE (T+S+I+P)**		⇨	247,400	
12-19	**Mode of payment**		Transmittal fee: revenue stamps Search fee: bank draft International fee: bank draft Priority document fee: revenue stamps		

VALIDATION LOG AND REMARKS

13-1-1	**Applicant remarks** Annotate	7642 Patent Attorney OHTSUKA Yasunori

PCT (ANNEX - FEE CALCULATION SHEET)

Original (for SUBMISSION) - printed on 20.04.2001 10:57:42 AM

P201-0084PCT

13-2-2	Validation messages States	Green? More designations could be made. The following States have not been designated: AP:(GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW); EA:(AM, AZ, BY, KG, KZ, MD, RU, TJ, TM); EP:(AT, BE, CH, LI, CY, DK, FI, GR, IE, LU, MC, NL, PT, SE, TR); OA:(BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG); AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, LI, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW. Please verify.
		Green? One or more states has been deselected from the EP designation. Please verify.
13-2-9	Validation messages Annotate	Green? All indications that can be made on the Request form are specifically provided for by the software. Please confirm validity of additional indication.
13-2-10	Validation messages For receiving Office/International Bureau use only	Green? Verify electronic data for consistency against printed form.

2001A006
P201-0084

POWER OF ATTORNEY

We, the undersigned, hereby appoint Yasunori OHTSUKA, registered patent attorney, as our attorney and hereby grant the above named attorney the power:

1. To act for us in all matters relating to the international application, under the Patent Cooperation Treaty entitled:

METHOD OF PROCESSING METAL MEMBERS

2. To withdraw the above identified international application or the designated State; and

3. To act in all matters relating to a demand for the international preliminary examination with respect to the above identified international application and to withdraw the demand or the election of any elected State.

Name: GENDOH Toshiyuki
Address: c/o MAZDA MOTOR CORPORATION,
3-1, Shinchi, Fuchu-cho, Aki-gun,
Hiroshima 735-0028, Japan
Signature: Toshiyuki Gendoh
Date: April 10, 2001

Name: NOMURA Seiji
Address: c/o MAZDA MOTOR CORPORATION,
3-1, Shinchi, Fuchu-cho, Aki-gun,
Hiroshima 735-0028, Japan
Signature: Seiji Nomura
Date: April 10, 2001

2001A006
P201-0084

POWER OF ATTORNEY

We, the undersigned, hereby appoint Yasunori OHTSUKA, registered patent attorney, as our attorney and hereby grant the above named attorney the power:

1. To act for us in all matters relating to the international application, under the Patent Cooperation Treaty entitled:

METHOD OF PROCESSING METAL MEMBERS

2. To withdraw the above identified international application or the designated State; and

3. To act in all matters relating to a demand for the international preliminary examination with respect to the above identified international application and to withdraw the demand or the election of any elected State.

Name: MAZDA MOTOR CORPORATION
FIELDS, Mark
President

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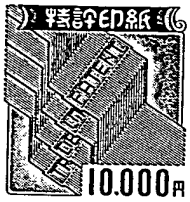
Hiroshima 735-0028, Japan

Signature: _____

Date: 4/11/01



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弁理士 大塚康徳之印

ご依頼日 13年04月20日

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(おなまえ) [illegible] 大塚康徳 様

(おところ) [illegible]

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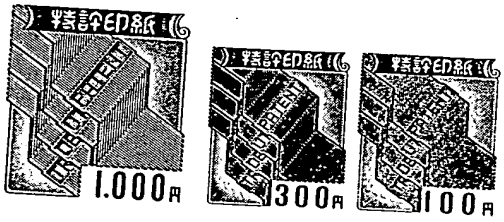

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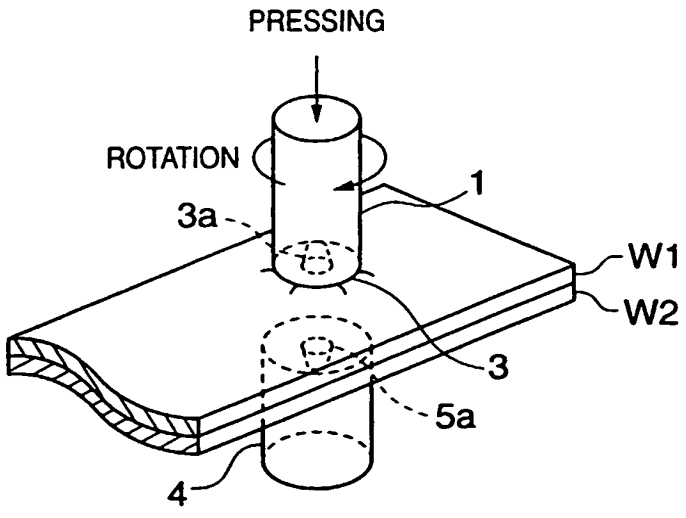


(57) Abstract: First and second metal members (W1, W2) are joined by lapping at least two metal members one over the other; pressing a rotating tool (1) against the outmost surface of the lapped metal members, that is, the first metal member (W1); and stirring the metal structure between the first and second metal members (W1, W2) by the use of frictional heat generated by the rotating motion of the rotating tool (1) while keeping the metal members in a non-molten state.

WO 01/83153 A1

DESCRIPTION

METHOD OF PROCESSING METAL MEMBERS

Technical Field

The present invention relates to a method of processing metal members such as aluminum alloy castings and plate materials.

Background Art

In the current joining techniques, metal members such as plate materials or those having been press-formed into three-dimensional shapes are lapped one over the other and joined together by the use of resistance welding or arc welding, joining materials, bolt fastening, rivets, etc.

And if metal members are of complicated three-dimensional shape, the spot welding process is used in which a plurality of portions to be welded spotted in the metal members can be welded locally.

And as another joining technique, there is disclosed in Japanese Patent No. 2712838 a joining process in which metal members are stirred by the use of friction while being kept in a non-molten state. This joining technique is to join two metal members in the following steps of: inserting and translating a projected portion referred to as probe into the surface of the metal members subjected to welding, where two metal members are butted together, while rotating

the probe; and plasticizing the metal structure in the vicinity of the above surface by the use of frictional heat generated by the rotating motion of the above probe.

In the joining technique described in the above patent, however, since the probe is inserted into and moved through the surface of the metal members, there remain traces of welding (holes) at the starting- and end-points of the probe's movement locus. This causes problems involving: the appearance of the metal members, that is, the metal members being unable to be used for the parts where the traces of welding are visible; the need to form an excess metal portion beforehand and locate the probe's stating- and end-points in such a portion so as to remove the traces of welding in the secondary processing; and the decrease in fatigue strength of the metal members if some traces of welding should remain.

Disclosure of Invention

The present invention has been made in light of the above problems; accordingly, the object of the present invention is to provide a method of processing metal members which enables the construction of a strong member to member junction without causing thermal distortion and a trace of welding.

In order to overcome the above problems and achieve the above object, the method of processing metal members according to the present invention is to join first and

second metal members by lapping at least two metal members one over the other; pressing a planar tip of a rotor against the above first metal member; rotating the above rotor and stirring the portion of the above first metal member subjected to joining by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer while expanding the non-molten stirred layer to said second metal member.

According to this construction, metal members can be strongly joined without causing thermal distortion and a trace of welding.

Preferably a concave portion is formed in the tip of the above rotor. According to this construction, the stirring characteristics to the first and second metal members can be improved.

Preferably concave and convex portions differing in height in the circumferential direction are formed in the tip of the above rotor. According to this construction, metal members can be strongly joined without causing thermal distortion and a trace of welding.

Preferably a receiving member is provided in such a manner as to face the tip portion of the above rotor via the first and second metal members and a concave portion is formed in the tip portion of the above receiving member. According to this construction, the joining duration can be shortened. In addition, joining can be satisfactorily

performed even if the total thickness of the metal members or the number of lapped metal members are large.

Preferably another rotor is provided in such a manner as to face the tip portion of the above rotor via the first and second metal members, the two rotors being rotated in the opposite direction with the first and second metal members interposed between them.

According to this construction, the joining duration can be shortened, in addition, joining can be satisfactorily performed even if the total thickness of the metal members or the number of lapped metal members are large.

Preferably the first and second metal members are continuously joined while moving the above rotor. This enables a strong metal member to metal member junction without causing thermal distortion and a trace of welding.

Preferably the tip portion of the above rotor is pressed from the side of one metal member of which thickness is smaller the other one. This enables the acceleration of the expansion of the non-molten stirred layer from the first metal member to the second metal member.

Preferably the above first and second metal members are joined in the following steps of: allowing an alloy material, which can mutually diffuse with the above first and second metal members, to intervene between the above first and second metal members at the portion subjected to joining; pressing and rotating the above rotor against the

portion of the above first and second metal members subjected to joining, and stirring the same portion by the use of friction caused by the rotating motion of the above rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer while expanding the non-molten stirred layer to said second metal member.

According to this construction, due to the use of an alloy material, a high joining strength can be obtained, in addition, different kinds of metal members can also be joined.

Preferably the above first and second metal members are joined while removing burrs produced on the above first metal member in the vicinity of the above rotor due to the rotating and pressing motion of said rotor.

This enables the simplification of deburring processing after the completion of joining metal members.

A method of processing a metal member of the present invention is to reform the surface of the metal member in the following steps of: pressing a planar tip of a rotor against the above metal member; rotating the above rotor and stirring the above metal member by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state.

This enables refinement of the metal structure and decrease in casting defects, thereby the material characteristics such as thermal fatigue (low cycle fatigue) life, elongation and impact resistance can be improved.

Brief Description of Drawings

FIG. 1 is an enlarged view of a rotating tool and vicinity illustrating a lap joining method of an embodiment according to the present invention;

FIGS. 2A, 2B, 3A, 3B, 4A and 4B are views illustrating the shapes of the tip portions 3 of various possible types rotating tools 1, FIGS. 2A, 3A and 4A being the side views of the rotating tools, FIGS. 2B, 3B and 4B being the front views of the tip portions;

FIG. 5 is a schematic view of an articulated type robot which holds and drives a rotating tool;

FIG. 6 is a view illustrating a method of joining metal members;

FIG. 7 is a view illustrating a method of joining three or more metal members;

FIGS. 8A, 8B, 8C are views showing the plastic flow state within metal members when the tip portion of a rotating tool is flat;

FIGS. 9A, 9B and 9C are views showing the plastic flow state within metal members when a concave portion is formed in the tip portion of a rotating tool;

FIG. 10 is a view showing the plastic flow state within metal members when projections or grooves are formed in the tip portion of a rotating tool;

FIG. 11 is a schematic representation illustrating the method of testing the strength of the non-fusing frictionally-stirring joining of this embodiment;

FIG. 12 is a graph showing the results of the joining strength test conducted in accordance with the method shown in FIG. 11;

FIG. 13 is a view showing the case where body frames of an automobile are joined as metal members having been press-formed into three-dimensional shapes beforehand;

FIG. 14 is an enlarged view of a rotating tool and vicinity illustrating the case where joining is continuously performed while allowing the rotating tool to advance;

FIG. 15 is a view illustrating a method of joining metal members in which joining is continuously performed while allowing a rotating tool to advance;

FIG. 16 is a view of a rotating tool, as a variation of the rotating tool according to the embodiment of the present invention, with radially extended portions formed on its periphery;

FIG. 17 is a cross-sectional view of the metal members joined in accordance with the embodiment of the present invention, showing the metal structure of the joined portion;

FIG. 18 is a view showing a state of metal members at the time of button rupture at a joining strength test;

FIG. 19 is a view showing a state of metal members at the time of separation rupture at a joining strength test;

FIG. 20 is a cross-sectional photographical view of the metal members joined in accordance with the embodiment of the present invention, showing the metal structure of the joined portion, which corresponds to FIG. 17;

FIG. 21 is an enlarged photographical view of a portion I of FIG. 20;

FIG. 22 is a cross-sectional photographical view of the metal members, showing the metal structure of a portion II of FIG. 21;

FIG. 23 is an enlarged photographical view of FIG. 22;

FIGS. 24A, 24B and 24C are views illustrating a method of joining first and second metal members with an alloy material intervened between them;

FIGS. 25A, 25B and 25C are views illustrating a state in which an alloy material is diffusing at a portion P, where first and second metal members are subjected to joining;

FIGS. 26 to 29 are graphs showing the examples of controlling the number of revolutions and pressing force of a rotating tool in joining metal members;

FIGS. 30A, 30B, 30C and 30D are views showing the state in which a Zn-5Al layer and an aluminum alloy plate diffuse mutually to form a diffusion layer consisting of Al, Al-Zn, Zn-Al, Fe-Zn and Fe and subsequently to form an Al-Zn-Fe alloy layer, thereby the metal members are joined together;

FIG. 31 is a view of a tip portion of a rotating tool provided with cutting tips;

FIG. 32 is a view of a tip portion of a rotating tool provided with a burr suppressing bump;

FIG. 33 is a view illustrating the position on a rotating toll in which cutting tips or a burr suppressing bump is placed;

FIGS. 34A, 34B and 34C are views illustrating a method of deburring when a rotating toll is provided with cutting tips;

FIGS. 35A, 35B and 35C are views illustrating a method of deburring when a rotating toll is provided with a burr suppressing bump;

FIGS. 36A, 36B, 36C and 36D are views showing the case where cutting tips or a burr suppressing bump is provided in such a manner as to move up and down relative to the rotating tool and illustrating a method of deburring;

FIG. 37 is a table showing the percentage of the components contained in an aluminum alloy casting used for surface treatment; and

FIG. 38 is a view illustrating one example of the applications of the embodiment of the present invention to surface treatment, that is, illustrating a method of performing surface reforming treatment on the portion between the adjacent ports (the portion between valves) formed on a cylinder head of an automobile.

Best Mode for Carrying Out the Invention

In the following an embodiment of the present invention will be described in detail with reference to the accompanying drawings.

Referring to FIG. 1, there is shown an enlarged view of a rotating tool and vicinity illustrating a lap joining method of an embodiment according to the present invention.

The joining method of this embodiment applies to the joining of metal members such as aluminum alloy plate materials and those having been press-formed into three-dimensional shapes and is to join first and second metal members W1, W2 in the following steps of: lapping at least two metal members one over the other; pressing a rotating tool 1 against the outermost surface of the lapped members, that is, the first metal member W1; and stirring the metal structure between the first and second metal members W1 and W2 by the use of the frictional heat generated by the rotating motion of the rotating tool 1 while keeping the same in a non-molten state.

With this method, problems such as thermal distortion caused by, for example, the electric resistance welding can be gotten rid of because the metal structure is stirred while being kept in a non-molten state.

The terms "to stir the metal structure while keeping the same in a non-molten state" herein used means that the metal structure is softened by the frictional heat generated by the rotor's rotational motion under

temperatures lower than the lowest melting point of the components or eutectic contained in the metal material and stirred.

As shown in FIG. 1, the joining method involving stirring by the use of friction is to join first and second metal members W1, W2 in the following steps of: lapping at least two metal members W1, W2 one over the other; pressing a planar tip 3 of a cylindrical rotating tool 1 against the outermost surface of the lapped metal members, that is, the first metal member W1 while rotating the same around its axis; and stirring the portion of the above first and second metal members W1, W2 to be joined by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer while expanding the non-molten stirred layer to said second metal member W2.

And a receiving member 4 is provided in such a manner as to face the tip 3 of the rotating tool 1 across the first and second metal members W1, W2. The receiving member 4 is designed to have an outside diameter larger than that of the rotating tool 1.

The diameter ϕ1 of the rotating tool 1 is about 10 to 15 mm. Although both the rotating tool 1 and the receiving member 4 are non-wearing type tools formed of steel (super hard alloys etc.) with hardness higher that that of the metal members, the material of the metal members is not

intended to be limited to aluminum alloys as long as it is softer than that of the rotating tool 1.

As is also shown in FIG. 6, a concave portion 3a is formed almost in the center of the tip portion 3 of the rotating tool 1. And a concave portion 5a is formed almost in the center of the tip portion 5 of the receiving member 4.

The respective concave portions 3a and 5a can be provided in either the rotating tool 1 or the receiving member 4, or in both of them.

FIGS. 2A, 2B, 3A, 3B, 4A and 4B are views illustrating different shapes of the tip portions 3 of various types rotating tools 1, FIGS. 2A, 3A and 4A being side views of the rotating tools, FIGS. 2B, 3B and 3C being front views of the tip portions.

In the rotating tool 1 shown in FIGS. 2A and 2B, the tip portion 3 is formed in such a manner as to have a slope relative to the contact surface on which it comes in contact with the metal member and configured so that the height from the contact surface can vary. And in the rotating tool 1 shown in FIGS. 3A and 3B, the planar tip portion 3 is provided with a plurality of projections (or grooves) 3b radiating from its center to the periphery. In the rotating tool 1 shown in FIGS. 4A and 4B, the planar tip portion 3 is provided with at least one groove (or projection) 3c running from its center to the periphery so that the height of the tip portion varies in the circumferential direction.

The rotating tool 1 has only to have an unevenness or a wavy finish in the circumferential direction of the tip portion, and it can be formed by combining the concave portion 3a shown in FIG. 1 with any one of the shapes of the tip portions 3 shown in FIGS. 2A, 2B, 3A, 3B, 4A and 4B. Or the rotating tool 1 having any one of the shapes shown in FIG. 3A, 3B, 4A and 4B can be formed by combining projections with grooves. Too high projections and too deep grooves are not suitable since the stirring characteristics of the rotating tool 1 to the metal members deteriorate.

The rotating tool 1 is attached to the arm of an articulated type robot 10 described later in a rotatable manner and is formed in such a manner that, when the metal members to be joined have complicated three-dimensional shapes, it can join them locally at a plurality of portions spotted in the metal members to be welded.

FIG. 5 is a schematic view of an articulated type robot which holds and drives a rotating tool.

As shown in FIG. 5, the articulated type robot 10 is connected to a joint 12 provided in the base 11 and swings around the y-axis, and it includes a first arm 14 rotating around the z-axis at a joint 13, a second arm 17 connected to the first arm 14 via a joint 15 and swinging around the y-axis while rotating around the x-axis at a joint 16, and a third arm 19 connected to the second arm 17 via a joint 18 and swinging around the y-axis.

The third arm 19 is to have a rotating tool 1 attached thereto in a rotatable manner and includes a motor 20 for rotatablly driving the rotating tool 1 and a receiving member 4 arranged in such a manner as to face the tip portion 3 of the rotating tool 1. The spacing between the tip portion 3 of the rotating tool 1 and the tip portion of the receiving member 4 is variable with an actuator 22 and is designed so that it can deal with the pressing force exerted on metal members during the joining operation and with three or more metal members lapped one over the other.

The operation of the arms, motor and actuator of the articulated type robot 10 is taught the robot beforehand and controlled by a control portion 30.

The pressing force to be exerted by the rotating tool 1 on the metal members is set for each joining portion based on the total plate thickness and lapping number of the metal members, and this applies to the case where plate thickness differs from member to member.

When joining three or more metal members, for example, a first metal member W1 to a third metal member W3, the joining is performed using a pair of rotating tools 1A, 1B the same in outside diameter in such a manner as to interpose the metal members between them, as shown in FIG. 7. In this case, the rotating tool 1B, instead of the receiving member 4 shown in FIG. 5, is attached to the articulated type robot 10 in a rotatable manner, and the rotating tools 1A, 1B are rotated in the opposite direction to each other with the

first metal member W1 to the third metal member W3 interposed between their tip portions 3A, 3B which are facing each other.

Even if the first and second metal members W1, W2 are different in thickness, they can be joined; and stirring becomes easier particularly when pressing the rotating tool 1 from the side of the metal member of smaller thickness, thereby uniform joining processing can be realized.

[Plastic Flow of Metal Structure during Joining]

FIGS. 8A, 8B and 8C are views showing the plastic flow state within metal members when the tip portion of a rotating tool is flat. FIGS. 9A, 9B and 9C are views showing the plastic flow state within metal members when a concave portion is formed in the tip portion of a rotating tool.

As shown in FIGS. 8A, 8B and 8C, in cases where a rotating tool 1 is used of which tip portion 3 is flat (for convenience in description, the tip portion 5 of a receiving member 4 shall be flat), when continuing to press the rotating tool 1 rotating at given rpm against a first metal member W1 in the direction almost perpendicular to the same, friction is caused between the rotating tool 1 and the first metal member W1, thereby the surface of the first metal member W1 is softened, and the metal structure between the first and second metal members W1, W2 gets stirred in such a direction that the rotating tool 1 rotates while being kept in a non-molten state. And increasing the pressing force of the rotating tool 1 against the first metal member

W1 expands the non-molten frictionally-stirred layer to the metal member W2, which is out of contact with the rotating tool 1, and finally the first and second metal members W1, W2 lapped one over the other are joined together while being kept in a non-molten state.

As shown in FIGS. 9A, 9B and 9C, in cases where a rotating tool 1 with a concave portion 3a formed in its tip portion 3 is used (for convenience in description, the tip portion 5 of a receiving member 4 shall be flat), when continuing to press the rotating tool 1 rotating at given rpm against a first metal member W1 in the direction almost perpendicular to the same, friction is caused between the rotating tool 1 and the first metal member W1, thereby the surface of the first metal member W1 is softened, and the metal structure between the first and second metal members W1, W2 gets stirred in such a direction that the rotating tool 1 rotates while being kept in a non-molten state. And increasing the pressing force of the rotating tool 1 against the first metal member W1 starts to expand the non-molten frictionally-stirred layer to the second metal member W2, which is out of contact with the rotating tool 1. At this time, the metal structure gets stirred in such a direction that the tool 1 rotates and at the same time gets stirred in the direction of its thickness (in the direction perpendicular to the surface of the metal members to be joined) within the concave portion 3a, and finally the first

and second metal members W1, W2 lapped one over the other are joined together while being kept in a non-molten state.

Providing a concave portion 3a in the rotating tool 1 promotes the plastic flow within the concave portion, where the circumferential speed of the metal structure stirred is almost zero, and providing a concave portion 5a in the receiving member 4 promotes the plastic flow of the metal member out of contact with the rotating tool 1.

As shown in FIG. 10, in cases where a rotating tool 1 with projections (or grooves) 3b formed in its tip portion 3 is used (for convenience in description, the tip portion 5 of a receiving member 4 shall be flat), the metal structure is stirred in such a direction that the tool 1 rotates due to the radial unevenness formed in the tip portion 3, and at the same time, the interface between first and second metal members W1, W2 is subjected to plastic flow periodically changing its direction up and down (the direction perpendicular to the metal members' surface to be joined) according to the rotation of the tool 1. This periodical up-and-down plastic flow promotes the diffusion of the interface between the two metal members, and finally the first and second metal members W1, W2 lapped one over the other are joined together while being kept in a non-molten state.

As described above, in cases where the tip portion 3 of the rotating tool 1 is provided with a concave portion 3a, the entire metal structure to be joined is fully

stirred; therefore, the joining strength of the metal members is increased. On the other hand, in cases where the tip portion 3 of the rotating tool 1 is not provided with a concave portion 3a and is flat, the metal structure is not fully stirred in the direction perpendicular to the surface of the metal members to be joined; therefore, the joining strength becomes low.

In cases where an radial unevenness is formed in the rotating tool 1, the state in which the tip portion of the rotating tool 1 is in contact with the metal structure is different from that of the cases where a concave portion 3a is formed in the same, and the angular speed of the metal structure subjected to stirring at the central portion can be set smaller than that of the circumferential portion; thus, the rotating tool 1 with a radial unevenness formed in its tip portion has the advantages over that with a concave portion 3a formed in its tip portion that it has excellent stirring characteristics and easily causes three-dimensional plastic flow, that is, plastic flow in such a direction that it rotates as well as up and down in a wider range of its tip portion.

[Test Results]

Although the joining processing of this embodiment used steel plates JIS 6000 (Al-Mg-Si steel plates) standardized in accordance with JIS as metal members, steel plates JIS 5000 (Al-Mg steel plates) and some other metal materials are also applicable.

FIG. 11 is a schematic representation illustrating the method of testing the strength of the non-fusing frictionally-stirring joining of this embodiment. FIG. 12 is a graph showing the results of the joining strength test conducted in accordance with the method shown in FIG. 11.

In the joining strength testing method shown in FIG. 11, the joining strength is indicated with the tensile force by which the joined surface is separated when pulling the first and second metal members W1, W2 in the opposite direction to each other.

The joining conditions were such that the revolution number of the rotating tool 1 was 2000 rpm, the tip portion 3 of the rotating tool 1 was 10 mm in diameter ϕ, the pressing duration meant the duration after pressing the rotating tool 1 against the metal members the depth of 0.2 mm, and the metal members used were JIS 6000 with thickness 1 mm.

As shown in FIG. 12, when using a rotating tool 1 with a concave portion 3a formed in it tip portion 3, the joining strength became higher than when using a rotating tool 1 with a flat tip portion 3 and the strength requirement was satisfied.

Further, in cases where a tool with a flat tip portion 3 was used, when trying to break the joined metal members, first a separation rupture occurred at the joined surface of the metal members, causing the metal members to separate from each other there, as shown in FIG. 19. On the other hand, in cases where a tool with a concave portion 3a formed

in its tip portion 3 was used, when trying to break the joined metal members, the metal members did not separate from each other at the joined surface, but first a button rupture occurred in which the portion Wa corresponding to the periphery of the rotating tool 1 ruptured, as shown in FIGS. 17 and 18. Thus, it is apparent that higher joining strength can be obtained when using a tool with a concave portion 3a formed in its tip portion 3.

Further, as shown in FIGS. 20 to 23, in cases where joining was performed using a tool with a concave portion 3a formed in its tip portion 3, since the interface between the metal members to be joined was fully stirred so as to be uniform, higher joining strength was obtained.

The longer the pressing duration of the rotating tool 1 against the metal members becomes, the higher the joining strength becomes; however, when the pressing duration is about 10 seconds or longer, almost the same joining strength can be obtained both in the use of the rotating tool 1 with a concave portion 3a formed in its tip portion 3 and in the use of the rotating tool 1 with a flat tip portion 3.

[Joining With Alloy Material Intervention]

First and second metal members can be joined with an alloy material intervened between them.

FIGS. 24A, 24B and 24C are views illustrating a method of joining first and second metal members with an alloy material intervened between them. FIGS. 25A, 25B and 25C are views illustrating a state in which the alloy material

is diffusing at a portion P, where the first and second metal members are subjected to joining.

As shown in FIGS. 24A, 24B, 24C, 25A, 25B and 25C, for example, the first metal member W1 is an aluminum alloy plate and the second metal member W2 is a Fe steel plate with a Zn-5Al or Zn hot-dipping layer Wc, as an alloy material, formed thereon via a Zn-Fe-Al or Zn-Fe alloy layer Wd. The Zn-5Al layer consists of a eutectic composition of about 95 % by weight Zn component and about 5 % by weight Al component. Preferably the Zn-5Al layer consisting of an aluminum alloy and Zn-5Al alloy material coated thereon is optimal. The Zn hot-dipping layer is commercially available in the form of a rust-preventive coating provided over a metal member.

When lapping the first and second metal members W1, W2 one over the other via the Zn-5Al or Zn hot-dipping layer Wc, as an alloy material, and pressing a rotating tool 1 against the surface portion of the first metal member W1 corresponding to the portion P joined to the second metal member W2, the aluminum alloy is stirred by friction caused by the rotation of the rotating tool 1 and starts plastic flow. When promoting the plastic flow, the oxide film on the surface of the aluminum alloy is broken and the Zn-5Al or Zn hot-dipping layer Wc and the aluminum alloy start to diffuse mutually to form a diffusion layer consisting of Al, Al-Zn, Zn-Al, Fe-Zn and Fe. And when further promoting the plastic flow, the diffusion layer becomes an

Al-Zn-Fe alloy layer We, and the aluminum alloy plate W1 and the steel plate W2 are joined together via the Al-Zn-Fe alloy layer We.

When joining a steel plate without Zn-5Al or Zn hot-dipping layer Wc and an aluminum alloy plate together, an alloy material such as a Zn-5Al layer or Zn alloy foil may be allowed to intervene specially between the two members just at the portion P to be joined. Further, as the alloy material, not only Zn-Al layer but also Mg-Al layer may be formed on the second metal member W2.

As a rotating tool 1, not only one with a flat tip portion but also ones with tip portions of various configurations can be used. A rotating tool with a projection 2, which is referred to as probe, provided on its tip portion may also be used.

The rotating tool 1 is pressed against any one of the first and second metal members W1, W2 which has a lower melting point than the other one, so as to stir the metal structure of the members by the use of friction caused by the rotating tool's rotation.

Pressing the rotating tool from the side of the aluminum alloy member, which is softened by little heating compared with the steel plate member having a higher melting point and a higher strength at elevated temperature than the aluminum alloy, allows the metal members to be joined in a short period of time, thereby reduces the thermal and

mechanical loads applied to the tool, and therefore, has the advantage that it can increase the tool life.

As shown in FIGS. 26 to 29, the number of revolutions of the rotating tool 1 against the metal members may be kept constant at about 1000 rpm (FIGS. 26, 27) or may be changed periodically so as to promote the breaking of the oxide film on the aluminum alloy member (FIGS. 28, 29). Decreasing the number of revolutions causes joining to take a longer time, therefore, is not preferable.

The pressing force of the rotating tool 1 against the metal members is kept constant (FIGS. 26, 28) or is gradually increased (FIGS. 27, 29). Decreasing the pressing force causes an unsatisfactory plastic flow, thereby makes it impossible to obtain satisfactory joining strength.

As for the relationship between the number of revolutions and the pressing force, the pressing force must be increased as the metal structure is softened.

[Diffusion Joining of Alloy Material]

FIGS. 30A, 30B, 30C and 30D are views showing the state in which a Zn-5Al layer and an aluminum alloy plate diffuse mutually to form a diffusion layer consisting of Al, Al-Zn, Zn-Al, Fe-Zn and Fe, then plastic flow is further promoted to form an Al-Zn-Fe alloy layer We, and finally the aluminum alloy plate W1 and a steel plate W2 is joined together via the Al-Zn-Fe alloy layer We.

When lapping the aluminum alloy plate and the Fe steel plate one over the other with a Zn-5Al layer intervening between them, as shown in FIG. 30A, and stirring the metal structure of the lapped plates by the use of friction caused by the rotating tool 1 while keeping the same in a non-molten state, a diffusion layer consisting of Al and Zn-5Al layers is formed at the bottom of the aluminum alloy plate and a diffusion layer consisting of Fe and Zn-5Al layers is formed on the top of the Fe steel plate, as shown in FIG. 30B.

When allowing the plastic flow to progress by further stirring the metal structure, Zn component of the Zn-5Al layer is further diffused in the aluminum alloy plate and Fe steel plate, and this diffusion reaction gradually decreases the ratio of Zn component (increases the ratio of Al component) in the Zn-5Al layer, as shown in FIG. 30C.

When allowing the plastic flow in the state shown in FIG. 30C to further progress, a diffusion reaction occurs between the diffusion layers on the aluminum alloy plate side and on the Fe steel plate side; as a result, an Al-Zn-Fe alloy layer is formed as shown in FIG. 30D.

As described above, the first and second metal members W1, W2 are joined together via an Al-Zn-Fe three-component system alloy layer. This can prevent a brittle intermetallic compound, that is, Fe-Al, from forming on the junction surface of the first metal member W1 and second

metal member W2; thus, the Al-Zn-Fe three-component system alloy layer allows a very high joining strength.

[Shape of Metal Members]

The embodiment of the present invention is suitable for joining metal members having been press-formed into three-dimensional shapes beforehand. Specifically, in cases where the metal members have been press-formed into complicated three-dimensional shapes and a plurality of portions P to be joined are so spotted that a rotating tool 1 cannot be moved continuously, like the case where a body frame W1 of an automobile and its reinforcing member W2 are joined, as shown in FIG. 13, if the joining method according to this embodiment is used, such metal members as are press-formed into complicated shapes can be locally welded and joined together.

[Deburring Structure]

FIG. 31 is a view of a tip portion of a rotating tool provided with cutting tips. FIG. 32 is a view of a tip portion of a rotating tool provided with a burr suppressing bump.

In order to remove burs Wb (refer to FIG. 17) produced on metal members during the joining operation, cutting tips 1b, which are radially extended portions, or a burr suppressing bump 1c may be integrally or separately formed on the periphery surface near the tip portion of a rotating toll 1 as shown in FIGS. 31 and 32.

The cutting tips 1b are flat and in parallel with the tip portion 3, and the periphery surface near the tip portion of the rotating tool 1 is provided with four cutting tips at 90° intervals. The cutting tips 1b are not necessarily flat, but they may be formed into spiral cutting blades for example. And the number of the tips can be set arbitrarily according to the components of the metal members and to the depth to which the rotating tool 1 is pressed.

The burr suppressing bump 1c is flat and in parallel with the tip portion 3 and is formed on the entire periphery surface near the tip portion 3 of the rotating tool 1.

FIGS. 34A, 34B and 34C are views illustrating a method of deburring when a rotating toll is provided with cutting tips. FIGS. 35A, 35B and 35C are views illustrating a method of deburring when a rotating toll is provided with a burr suppressing bump.

In cases where cutting tips 1b are used in removing burrs Wb, the burr Wb produced on a metal member W1 in the vicinity of a rotating tool 1 is cut away by rotating and pressing the rotating tool 1 against the metal member W1, as shown in FIGS. 34A, 34B and 34C.

In cases where a burr suppressing bump 1c is used in removing burrs Wb, the burr Wb produced on a metal member W1 in the vicinity of a rotating tool 1 is crushed by rotating and pressing the rotating tool 1 against the metal member W1, as shown in FIGS. 35A, 35B and 35C.

The cutting tips 1b or burr suppressing bump 1c is formed on the rotating tool 1 in such a position that it is axially away from the tip portion 3 by t, which is the depth to which the tip portion of the rotating tool 1 is pressed, as shown in FIG. 33.

The use of the cutting tips 1b allows complete deburring; however, it also allows chips Wb to be produced, in addition, makes the rotating tool 1 costly because hard cutting tips 1b must be used. On the other hand, the use of the burr suppressing bump 1c makes the junction surface a little inferior in appearance because the crushed burr Wb remains the junction surface; however, it has the advantages that the rotating tool 1 is not costly and chips are not produced.

The cutting tips 1b or burr suppressing bump 1c is not necessarily fixed on the rotating tool 1, it may be formed in such a manner as to move up and down coaxially relative to the axis of rotation of the rotating tool 1.

FIGS. 36A, 36B, 36C and 36D are views showing the case where cutting tips 1b or a burr suppressing bump 1c is provided in such a manner as to move up and down relative to the rotating tool and illustrating a method of deburring in such a case.

As shown in FIGS. 36A, 36B, 36C and 36D, the cutting tips 1b or burr suppressing bump 1c is provided on the tip portion of a hollow shaft 41 which can move up and down (or is rotatable around) the periphery surface of the rotating

tool 1 coaxially relative to the axis of rotation of the same.

In cases where this up-and-down type cutting tip 1b or burr suppressing bump 1c is used in removing burrs Wb, during the joining operation shown in FIGS. 36A and 36B, it is allowed to move up and be away from the portion to be joined, and after completion of the joining, it is allowed to move down, so as to remove the burr Wb by cutting or crushing the same, as shown in FIGS. 36C and 36D.

Allowing the cutting tips 1b or burr suppressing bump 1c to be movable requires complicated and expensive equipments compared with the case where the cutting tips 1b or burr suppressing bump 1c is fixed; however, it has the advantage that, when varying the pressing depth of the rotating tool according to the metal members, it can be dealt with by the same single tool.

[Continuous Joining]

In the above embodiment, one example of the spot joining has been described in which a rotating tool 1 is pressed against the portion of the metal members to be joined and not moved; however, joining may be performed continuously while allowing the rotating tool 1 to advance or swing, as shown in FIG. 14.

When allowing the rotating tool 1 to advance as shown in FIG. 14, if the rotating tool 1 is allowed to move while being tilted rearward at the angle of about 1° as shown in FIG. 15, its stirring characteristics are improved compared

with the case where it is pressed against the metal members perpendicularly.

[Variation]

As a variation of the embodiment of the present invention, joining can be performed while cooling the portion of the metal members to be joined, in order to suppress the distortion of metal members. As a cooling method, joining may be performed in cooling water, or cooling water may be supplied to the joining portion.

Further, in order to remove burrs Wb (refer to FIG. 17) produced on the metal members during the joining operation, radially extended portions 1a may be formed on the side surface of a rotating tool 1 near its tip portion. The radially extended portions 1a are formed on the rotating tool 1 in such a position that it is axially away from the tip portion 3 by a certain distance, which is the depth to which the tip portion of the rotating tool 1 is pressed. The radially extended portions 1a may also be used for holding the metal members down.

[Surface Treatment]

The joining technique in accordance with the embodiment of the present invention applies to the surface treatment of metal members.

The surface treatment is applied to aluminum alloy castings, and the technique is used in the surface reforming treatment of, in particular, the portions between the adjacent ports (portions between valves) formed on a

cylinder head, pistons and brake discs of automobiles. According to this technique, refinement of metal structure, uniform dispersion of eutectic silicon (Si) particles and decrease in casting defects can be realized by stirring the area of the aluminum alloy castings subjected to surface reforming treatment by the use of friction while keeping the same in a non-molten state, thereby the material characteristics, such as thermal fatigue (low cycle fatigue) life, elongation and impact resistance, more excellent than those obtained by the current remelting treatment can be obtained.

In the surface treatment according to the embodiment of the present invention, AC4D, which is an aluminum alloy standardized in accordance with JIS, was used as an example, as shown in FIG. 37; however, the component ratio of aluminum alloy castings can be changed within the following ranges: Mg content 0.2 to 1.5 % by weight; silicon (Si) content 1 to 24 % by weight, preferably 4 to 13 % by weight. And AC4B, AC2B, and AC8A for use in pistons can also be used. The reason that the upper limit of silicon content is set at 24 % is that, even if the content of silicon is increased to more than 24 %, the material characteristics and casting characteristics are saturated, moreover, the stirring characteristics deteriorate.

In aluminum alloy castings containing magnesium, their strength is increased when Mg_2Si is allowed to precipitate by heat treatment. However, in cases where the

metal structure of the aluminum alloy castings is refined by melting the same, like the case of the remelting treatment, magnesium, of which melting point is low (650°C), can sometimes evaporate and its content is decreased. The decrease in magnesium content lowers the hardness and strength of the aluminum alloy castings even if they are subjected to heat treatment, which makes it impossible to obtain desired material characteristics.

On the other hand, in the surface treatment adopting stirring by the use of friction, metal structure is never melted and magnesium component will not evaporate; thus, the strength of aluminum alloy castings can be increased when Mg_2Si is allowed to precipitate by heat treatment.

Addition of silicon to aluminum alloys improves their castability (fluidity of molten metal, shrink characteristics and hot cracking resistance); however, eutectic silicon acts as a kind of defect, thereby their mechanical properties (elongation) deteriorate.

Eutectic silicon causes decrease in elongation, since it is hard and brittle and acts as the origin and propagation path of cracking. It also causes decrease in fatigue life particularly at the portions between valves which are subjected to thermal stress repeatedly. In metal structure, such eutectic silicon ranges along a dendrite; however, if the eutectic silicon is refined and uniformly dispersed, occurrence of cracking due to the concentration of stress and its propagation can be suppressed.

FIG. 38 is a view illustrating an example of the applications of the embodiment of the present invention to surface treatment, that is, illustrating a method of performing surface reforming treatment on the portion between the adjacent ports (the portion between valves) formed on a cylinder head of an automobile.

As shown in FIG. 38, the surface reforming treatment is performed in such a manner as to move a rotating tool 1 across the portion between the valves of the adjacent ports along the treatment locus F1-F3 while stirring the same portion by the use of friction caused by the rotating tool's motion.

While the present invention has been described in terms of it preferred embodiment, it should be understood that various changes and modifications can be made in it without departing the spirit and scope thereof.

The present invention applies to the joining of any materials other than steel plates for use in automobiles.

CLAIMS

1. A method of processing metal members, wherein first and second metal members are joined by

lapping at least two metal members one over the other;

pressing a planar tip of a rotor against said first metal member;

rotating said rotor and stirring the portion of said first metal member to be joined by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer; and

expanding the non-molten stirred layer to said second metal member.

2. The method of processing metal members according to claim 1, wherein a concave portion is formed on the tip portion of said rotor.

3. The method of processing metal members according to claim 2, wherein concave and convex portions differing in height in the circumferential direction are formed on the tip portion of said rotor.

4. The method of processing metal members according to claim 1, wherein a receiving member is provided in such a manner as to face the tip portion of said rotor via the first

and second metal members and a concave portion is formed in the tip portion of said receiving member.

5. The method of processing metal members according to claim 1, wherein another rotor is provided in such a manner as to face the tip portion of said rotor via the first and second metal members, said two rotors being rotated in the opposite direction with the first and second metal members interposed between them.

6. The method of processing metal members according to claim 1, wherein the first and second metal members are continuously joined by moving said rotor.

7. The method of processing metal members according to claim 1, wherein the tip portion of said rotor is pressed from the side of one metal member of which thickness is smaller the other one.

8. The method of processing metal members according to claim 1, wherein said first and second metal members are joined by

allowing an alloy material, which can mutually diffuse with said first and second metal members, to intervene between said first and second metal members at the portion to be joined;

pressing and rotating said rotor against the portion of said first and second metal members to be joined, and stirring the same portion by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer; and

expanding the non-molten stirred layer to said second metal member.

9. The method of processing metal members according to claim 1, wherein said first and second metal members are joined while removing burrs produced on said first metal member in the vicinity of said rotor due to the rotating and pressing motion of said rotor.

10. A method of processing a metal member, wherein the surface of said metal members is reformed by

pressing a planar tip of a rotor against said metal member;

rotating said rotor and stirring said metal member by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state.

AMENDED CLAIMS

[received by the International Bureau on 24 August 2001 (24.08.01);
original claims 1-10 replaced by new claims 1-9 (3 pages)]

1. A method of processing metal members, wherein first and second metal members are joined by

lapping at least two metal members one over the other;

pressing a planar tip of a rotor against said first metal member;

rotating said rotor and stirring the portion of said first metal member in such a direction that the rotor rotates and a direction of a thickness of the metal members to be joined by the use of friction caused by the rotating motion of said rotor while keeping the metal members in a non-molten state, so as to form a non-molten stirred layer; and

expanding the non-molten stirred layer to said second metal member,

wherein a concave portion is formed on the tip portion of said rotor.

2. The method of processing metal members according to claim 1, wherein concave and convex portions differing in height in the circumferential direction are formed on the tip portion of said rotor.

3. The method of processing metal members according to claim 1, wherein a receiving member is provided in such a manner as to face the tip portion of said rotor via

the first and second metal members and a concave portion is formed in the tip portion of said receiving member.

4. The method of processing metal members according to claim 1, wherein another rotor is provided in such a manner as to face the tip portion of said rotor via the first and second metal members, said two rotors being rotated in the opposite direction with the first and second metal members interposed between them.

5. The method of processing metal members according to claim 1, wherein the first and second metal members are continuously joined by moving said rotor.

6. The method of processing metal members according to claim 1, wherein the tip portion of said rotor is pressed from the side of one metal member of which thickness is smaller the other one.

7. The method of processing metal members according to claim 1, wherein said first and second metal members are joined by

allowing an alloy material, which can mutually diffuse with said first and second metal members, to intervene between said first and second metal members at the portion to be joined;

pressing and rotating said rotor against the portion of said first and second metal members to be

joined, and stirring the same portion by the use of friction caused by the rotating motion of said rotor while keeping the same in a non-molten state, so as to form a non-molten stirred layer; and

expanding the non-molten stirred layer to said second metal member.

8. The method of processing metal members according to claim 1, wherein said first and second metal members are joined while removing burrs produced on said first metal member in the vicinity of said rotor due to the rotating and pressing motion of said rotor.

9. A method of processing a metal member, wherein the surface of said metal members is reformed by

pressing a planar tip of a rotor against said metal member;

rotating said rotor and stirring said metal member in such a direction that the rotor rotates and a direction of a thickness of the metal members by the use of friction caused by the rotating motion of said rotor while keeping the metal members in a non-molten state,

wherein a concave portion is formed on the tip portion of said rotor.

Statement Under Article 19(1)

GB 1 385 473 A shows a process for joining between metals by a frictional process by using a rotary tool, the rotary tool having a concave portion formed on the end portion of the rotary tool. However, it does not show that the metal members are stirred by friction of the rotor contacting with the metal members in such a direction that a rotor rotates and also stirred in a direction of a thickness of the metal members while keeping the metal members in a non-molten state.

US 4 144 110 A shows a process of adhesion between plastic sheets by a frictional process by using a rotary tool, the rotary tool having a concave portion formed on the end portion of the rotary tool. However, it does not show that the metal members are stirred by friction of the rotor contacting with the metal members in such a direction that a rotor rotates and also stirred in a direction of a thickness of the metal members while keeping the metal members in a non-molten state.

DE 197 46 812 A shows a process of joining between overlapped works by a frictional process by using a rotary tool, the rotary tool having a ball or hemisphere portion formed on the end portion. However, it does not show that the metal members are stirred by friction of a rotor contacting with the metal members in such a direction that a rotor rotates and also stirred in a direction of a thickness of the metal members while keeping the metal members in a non-molten state.

DE 197 31 638 A shows a process of joining between overlapped works by a frictional process by using a rotary tool, the rotary tool having a planar portion formed on the end portion. However, it does not show that the metal members are stirred by friction of a rotor contacting with the metal members in such a direction that a rotor rotates and also stirred in a direction

of a thickness of the metal members while keeping the metal members in a non-molten state.

EP 0 893 189 A shows a friction stir welding of two adjoining thickened parts by friction produced by an insertion of an rotary tool into a joining region, the rotary tool having a small-diameter tip end formed on the end portion. However, it does not show that overlapped metal members are stirred by friction of a rotor in such a direction that a rotor rotates and also stirred in a direction of a thickness of the metal members.

The present invention achieves an advantage in that the metal members can be strongly joined without causing thermal distortion and a trace of welding by stirring the metal members by the friction of the rotor having the concave portion formed on the end portion in the direction that the rotor rotates and also in the direction of the thickness of the metal members while keeping the metal members in a non-molten state.

FIG. 1

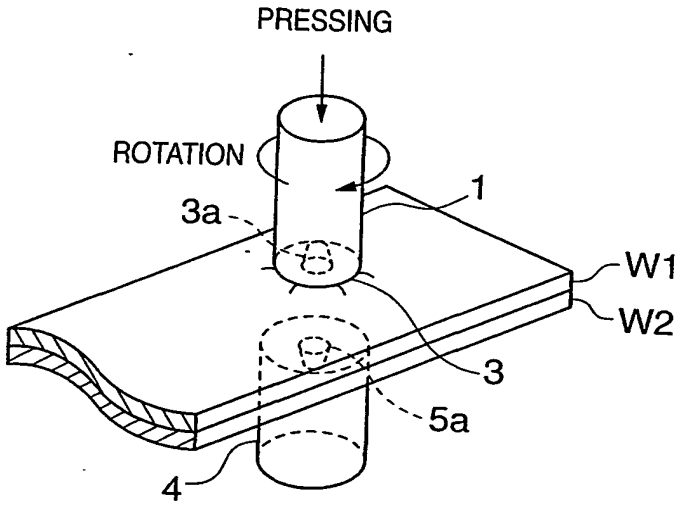


FIG. 2A

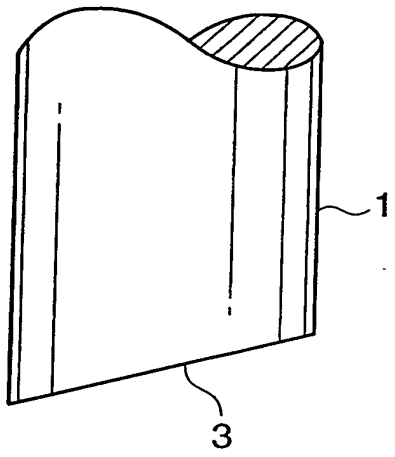


FIG. 2B

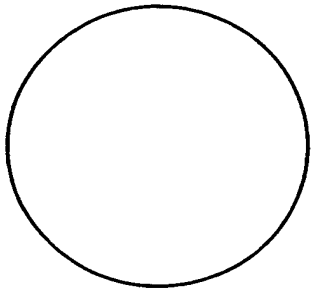


FIG. 3A

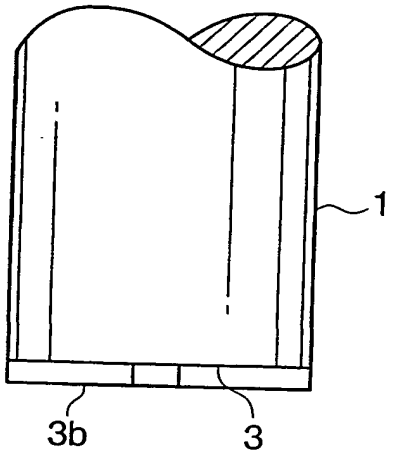


FIG. 3B

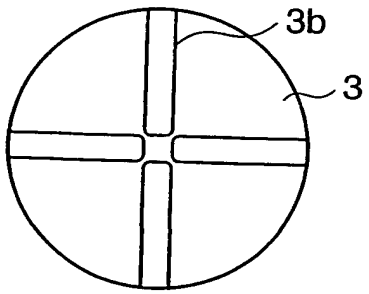


FIG. 4A

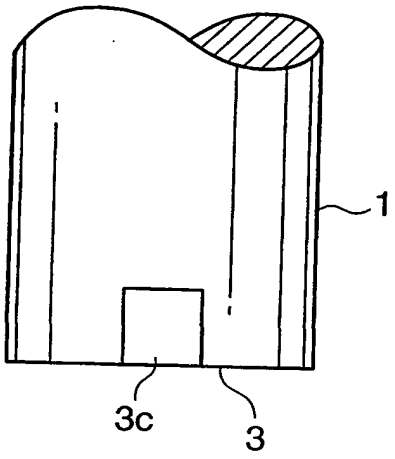


FIG. 4B

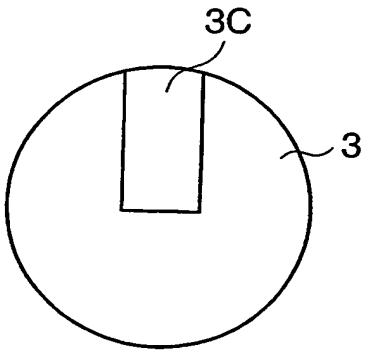


FIG. 5

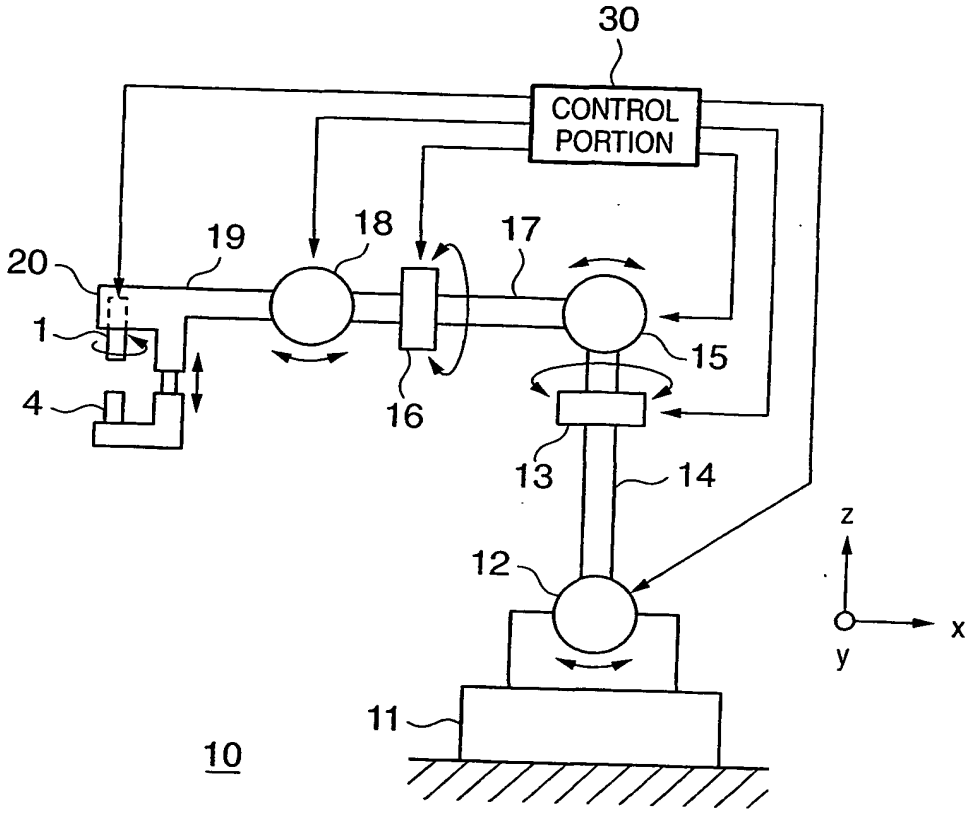


FIG. 6

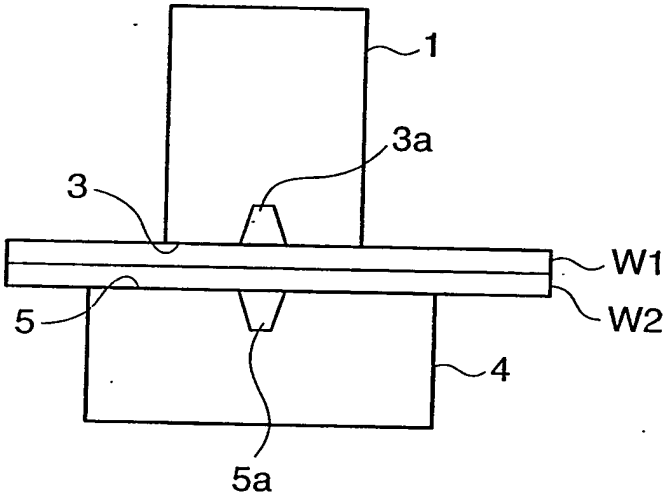


FIG. 7

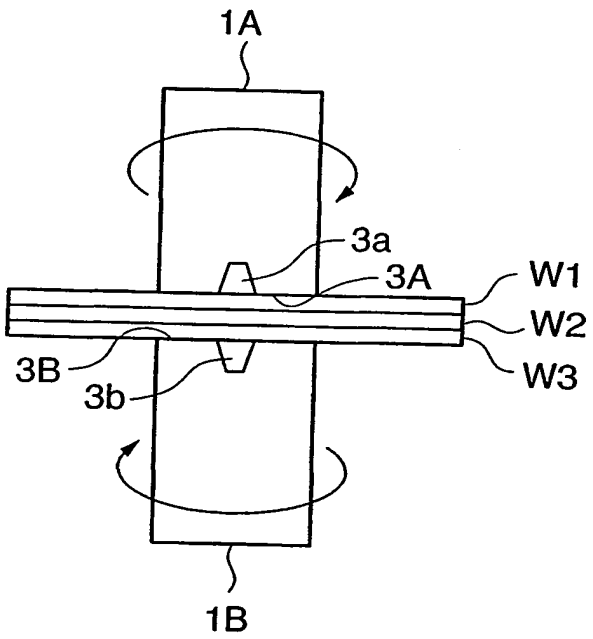


FIG. 8C

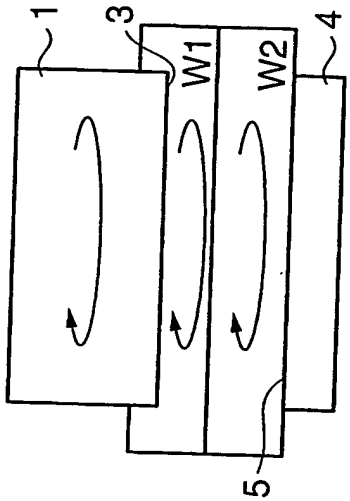


FIG. 8B

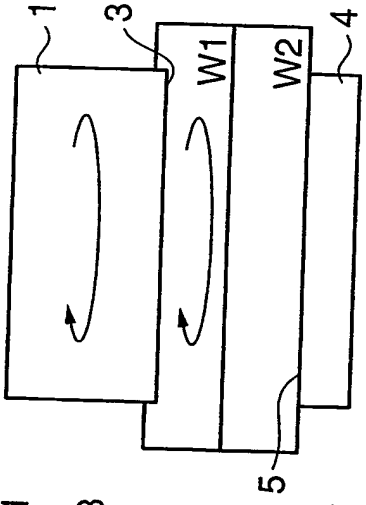


FIG. 8A

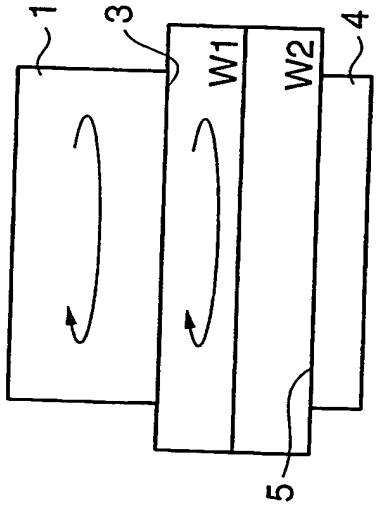


FIG. 9C

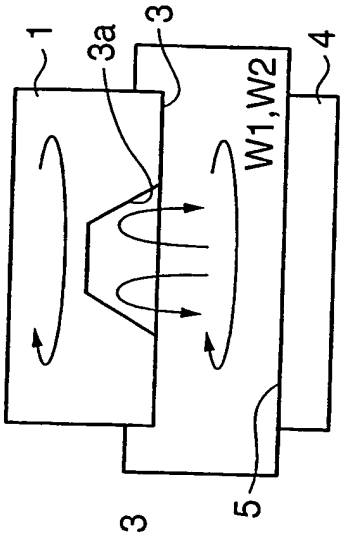


FIG. 9B

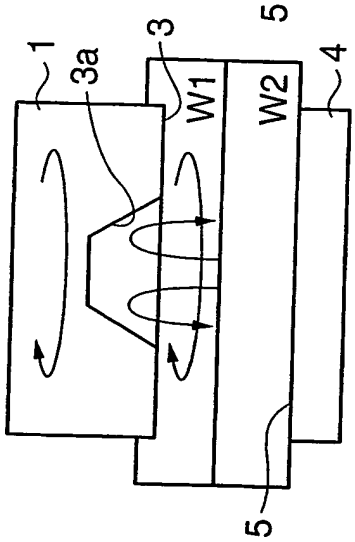


FIG. 9A

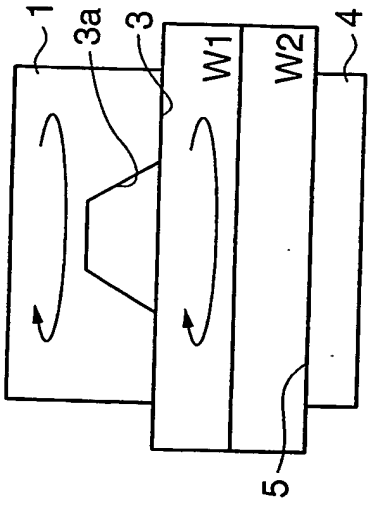


FIG. 10

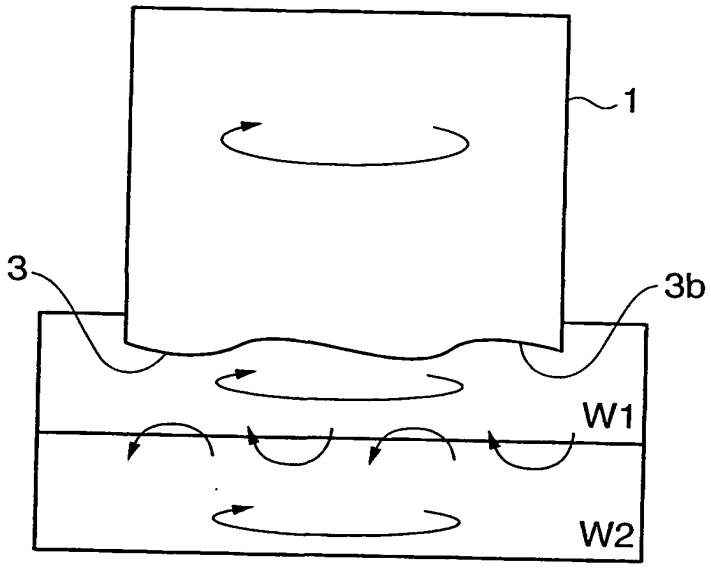


FIG. 11

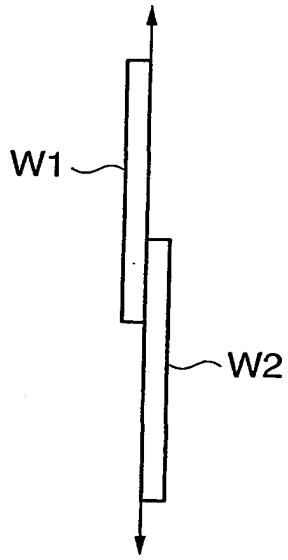


FIG. 12

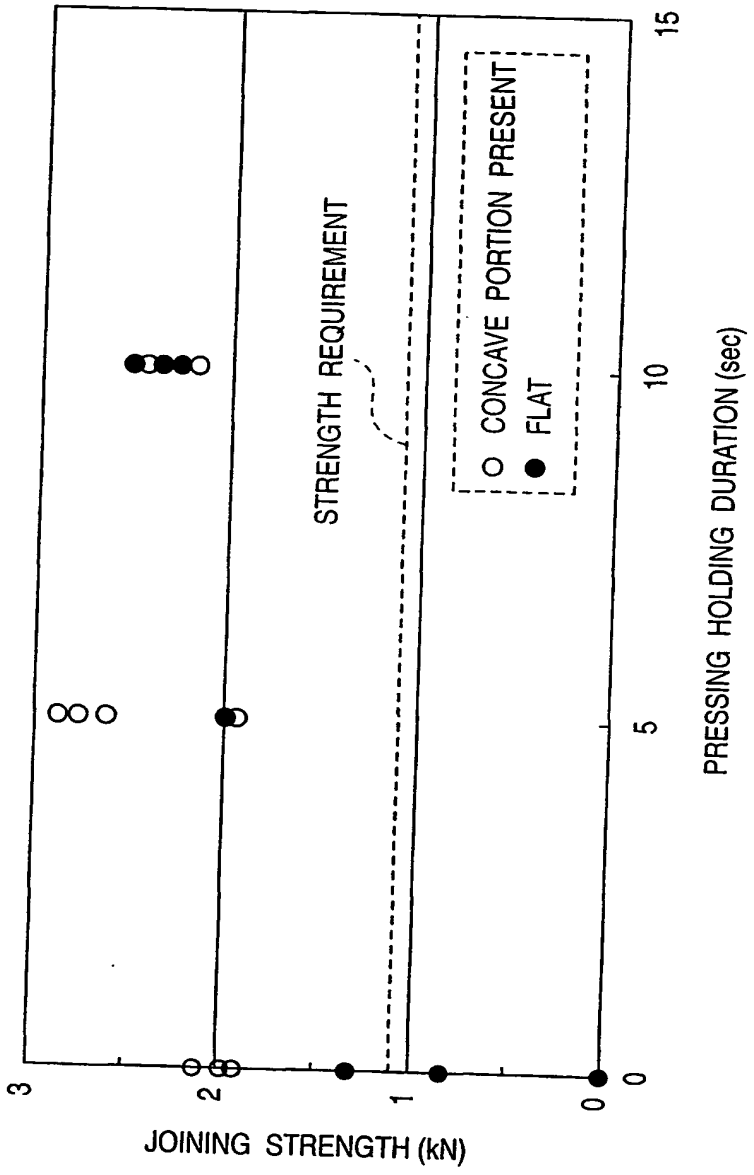

CONCAVE PORTION PRESENT
FLAT
STRENGTH REQUIREMENT
JOINING STRENGTH (kN)
PRESSING HOLDING DURATION (sec)
0
1
2
3
0
5
10
15

FIG. 13

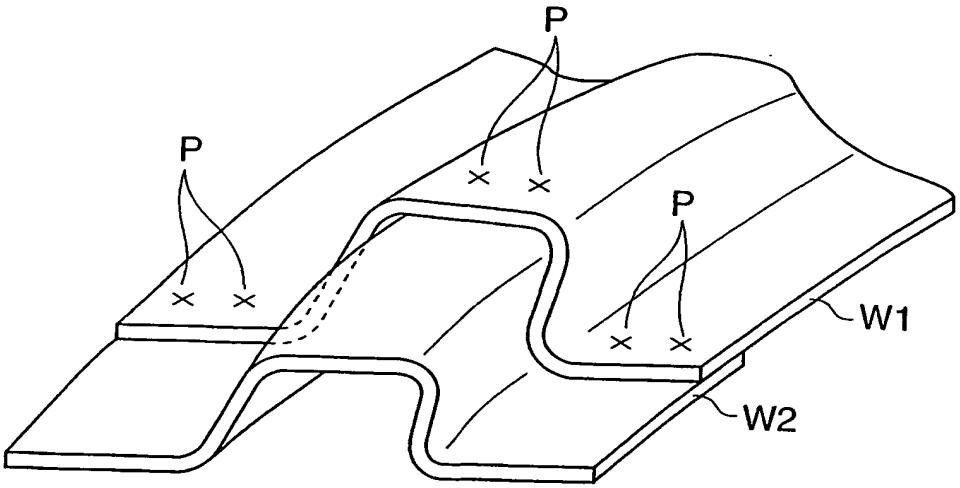


FIG. 14

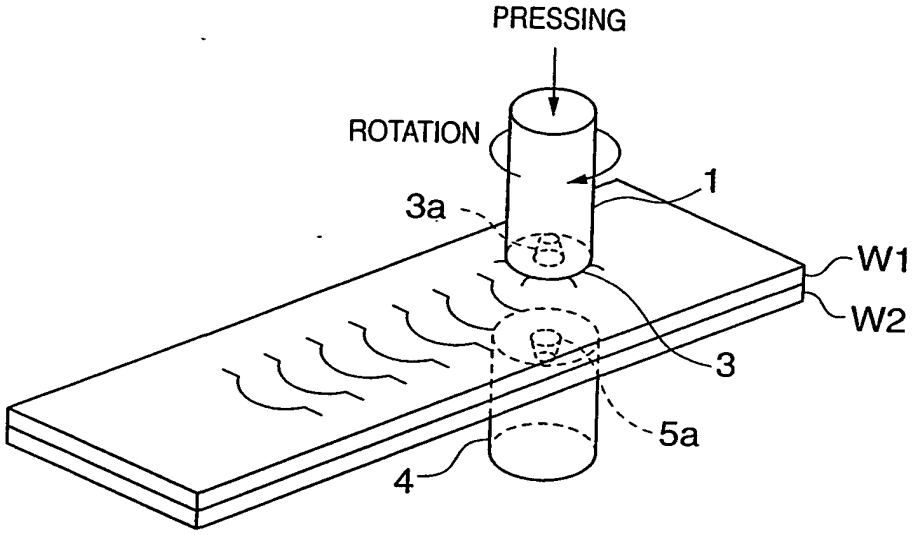


FIG. 15

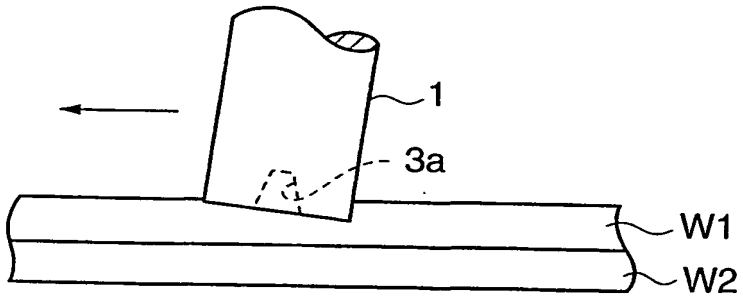


FIG. 16

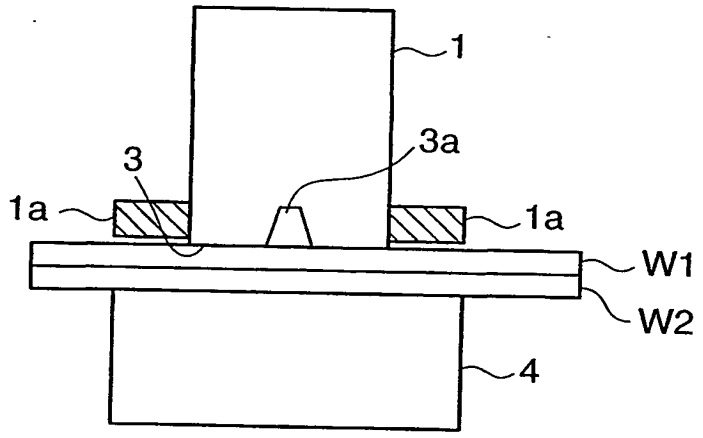


FIG. 17

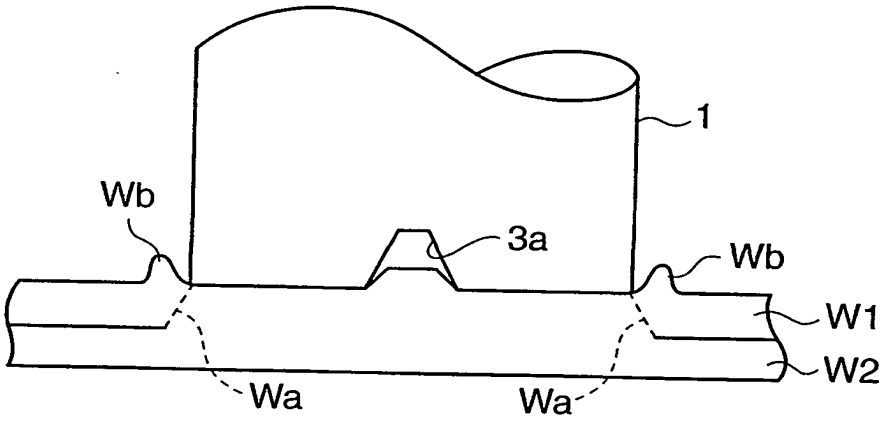


FIG. 18

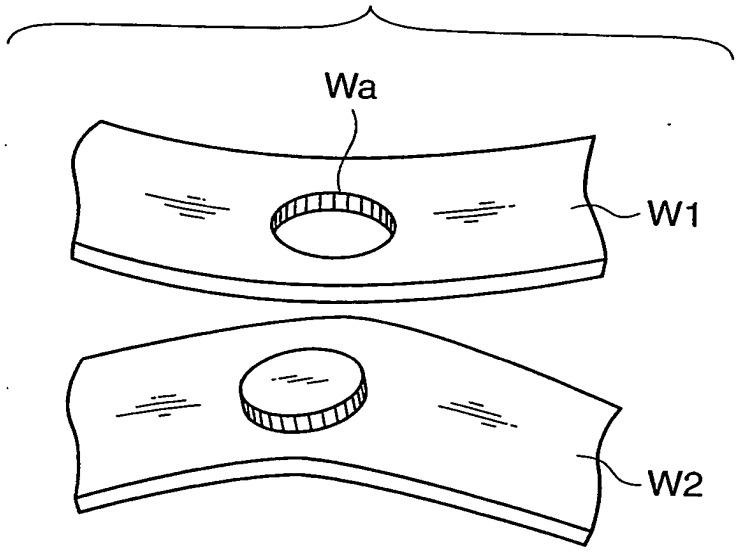


FIG. 19

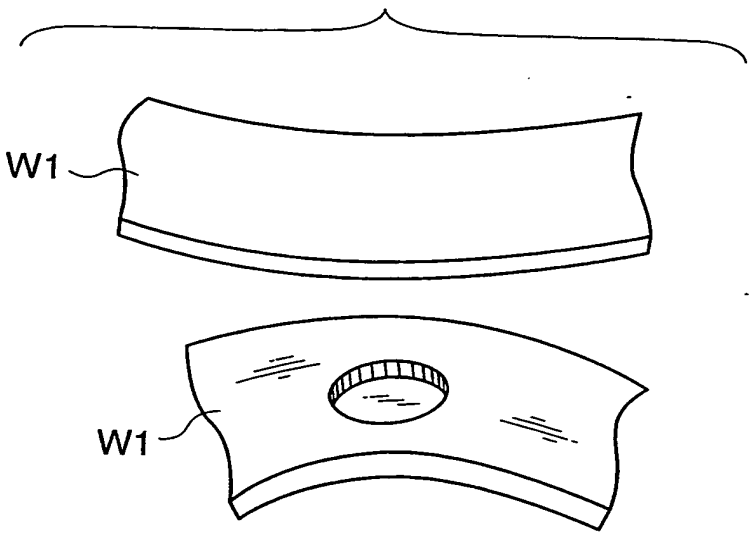


FIG. 20

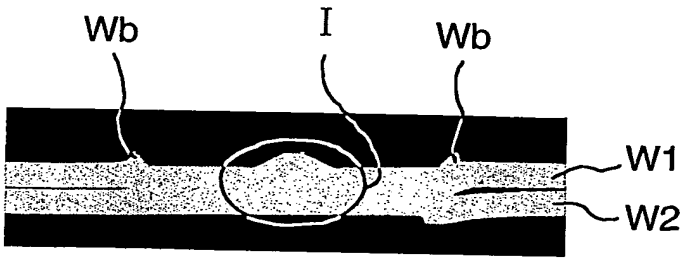


FIG. 21

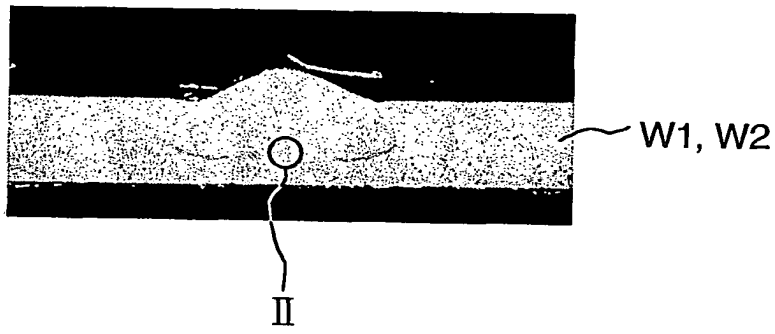


FIG. 22

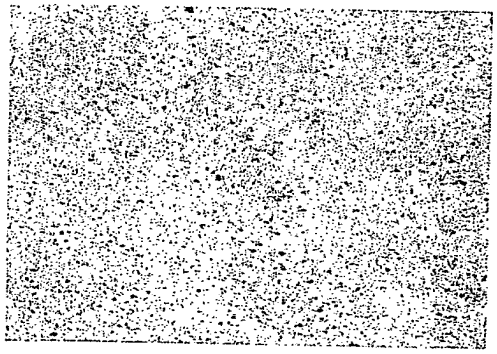


FIG. 23

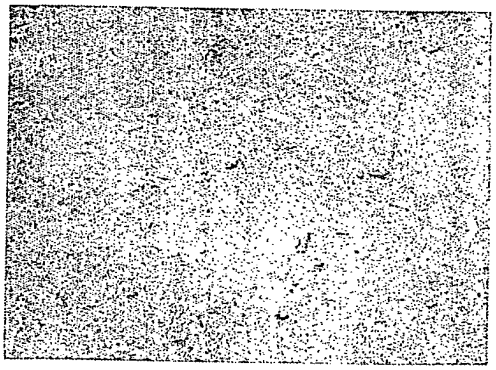


FIG. 24C

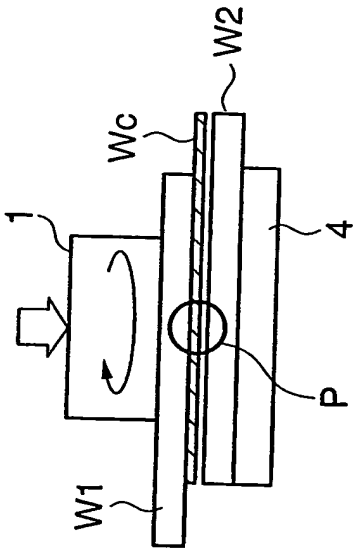


FIG. 24B

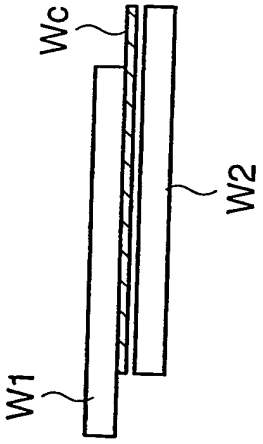


FIG. 24A

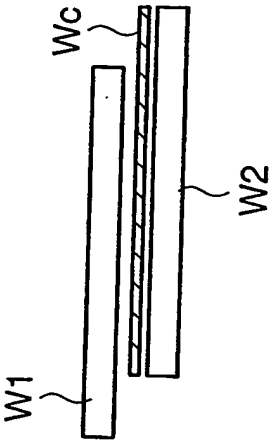


FIG. 25C

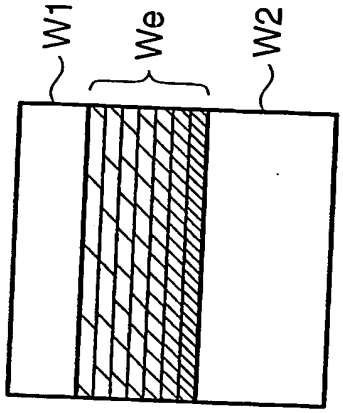


FIG. 25B

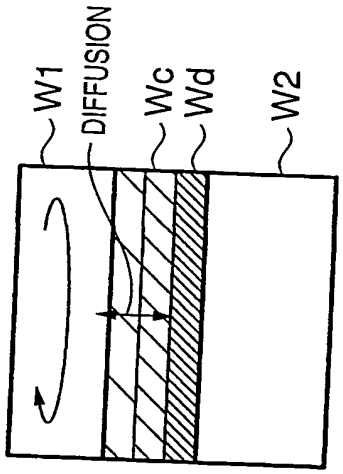


FIG. 25A

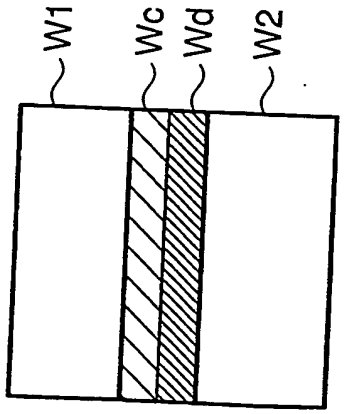


FIG. 26

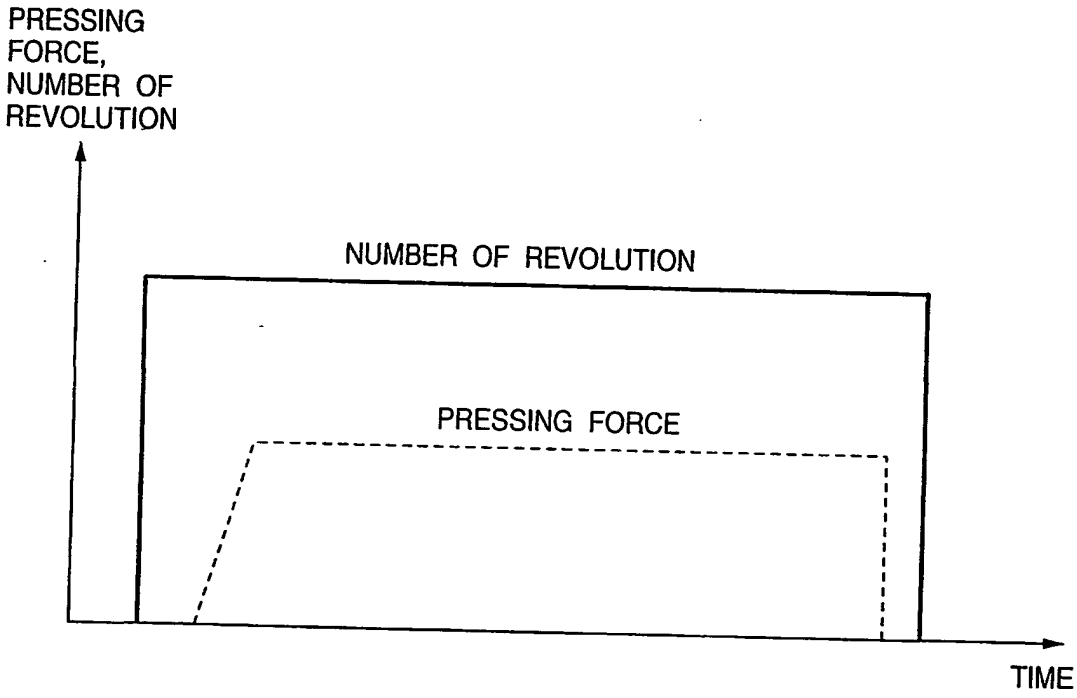

PRESSING FORCE, NUMBER OF REVOLUTION
NUMBER OF REVOLUTION
PRESSING FORCE
TIME

FIG. 27

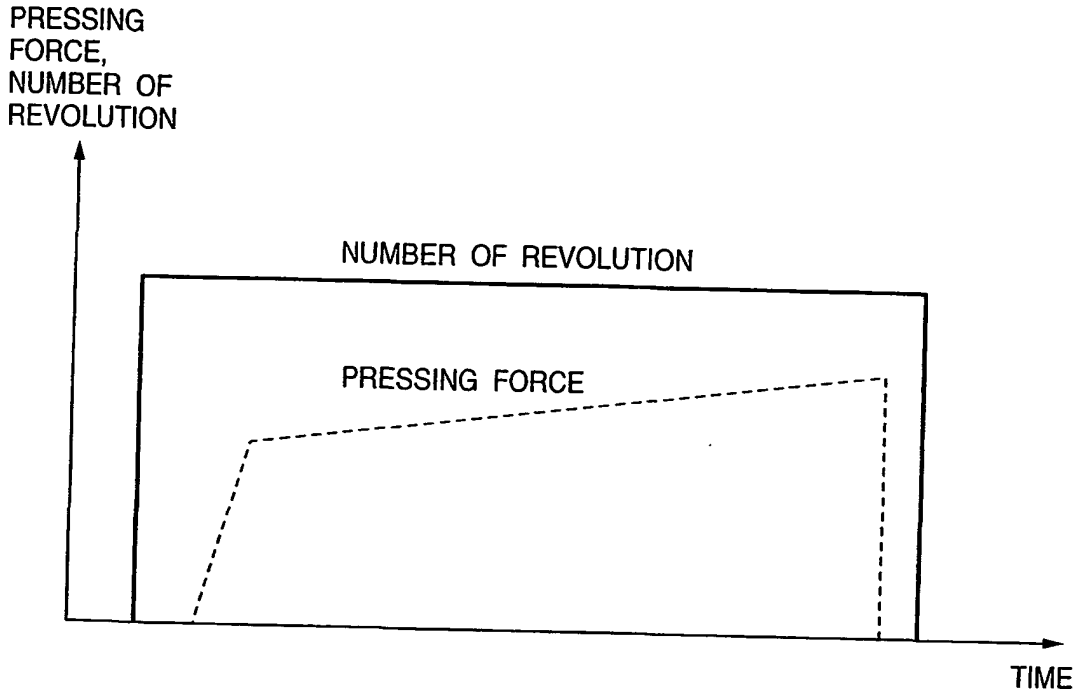

PRESSING FORCE, NUMBER OF REVOLUTION
NUMBER OF REVOLUTION
PRESSING FORCE
TIME

FIG. 28

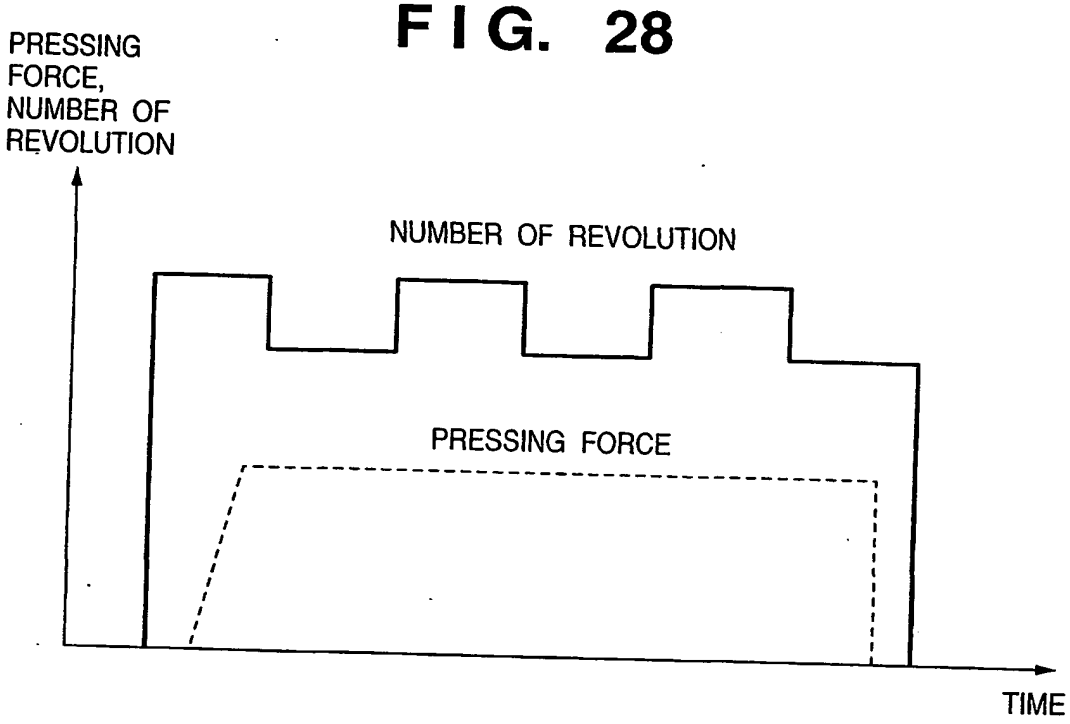

PRESSING FORCE, NUMBER OF REVOLUTION
NUMBER OF REVOLUTION
PRESSING FORCE
TIME

FIG. 29

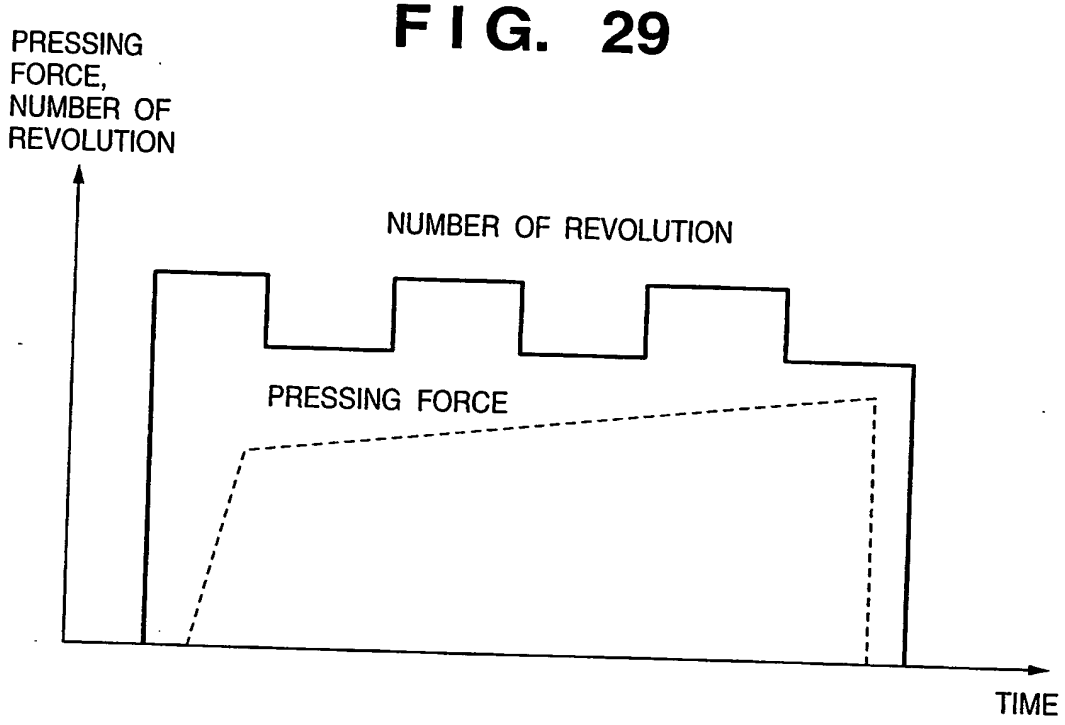

PRESSING FORCE, NUMBER OF REVOLUTION
NUMBER OF REVOLUTION
PRESSING FORCE
TIME

FIG. 30A

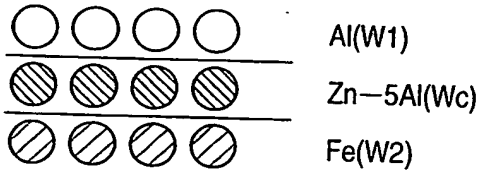


FIG. 30B

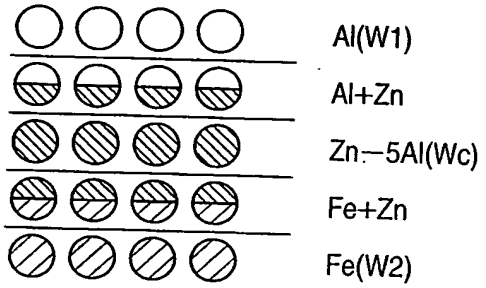


FIG. 30C

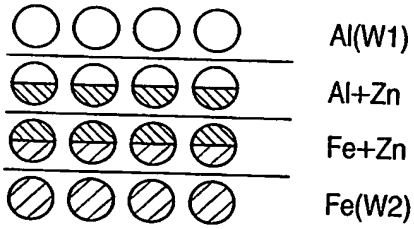


FIG. 30D

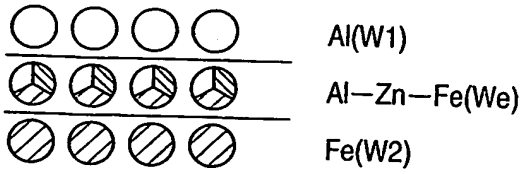


FIG. 31

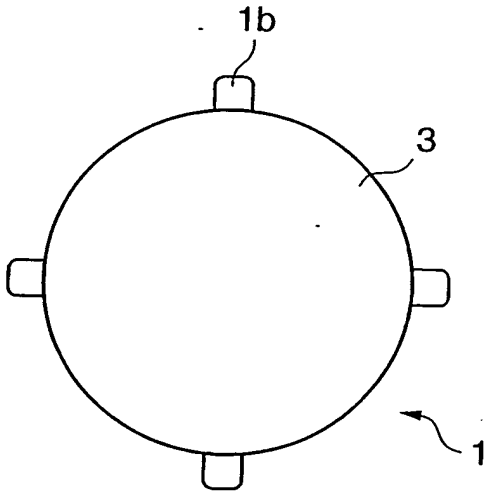


FIG. 32

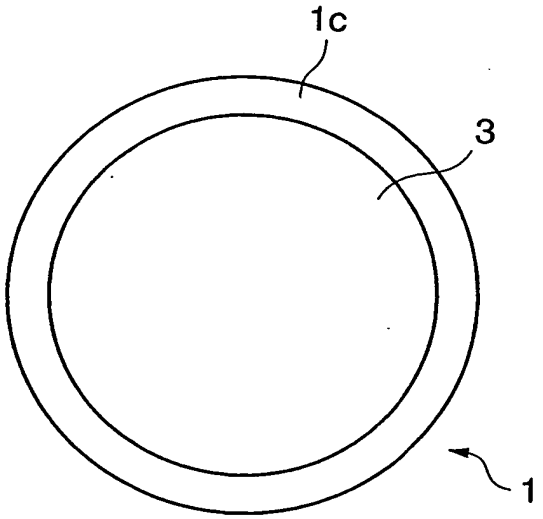


FIG. 33

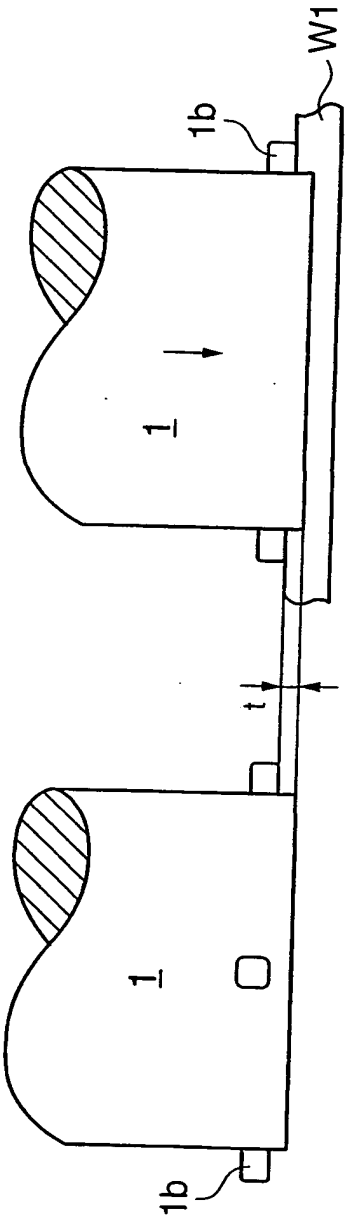


FIG. 34A

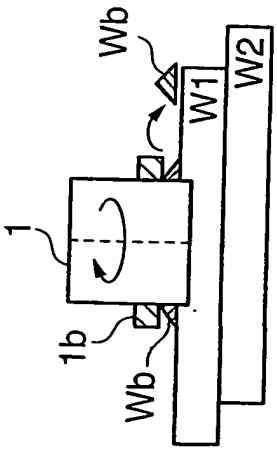


FIG. 34B

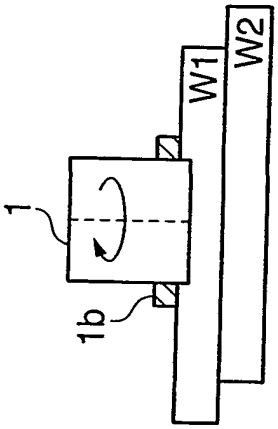


FIG. 34C

FIG. 35A

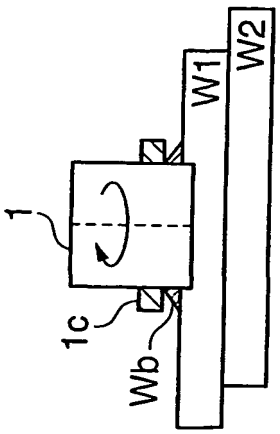


FIG. 35B

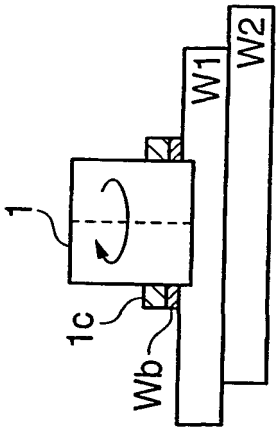
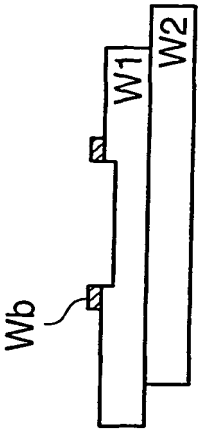


FIG. 35C



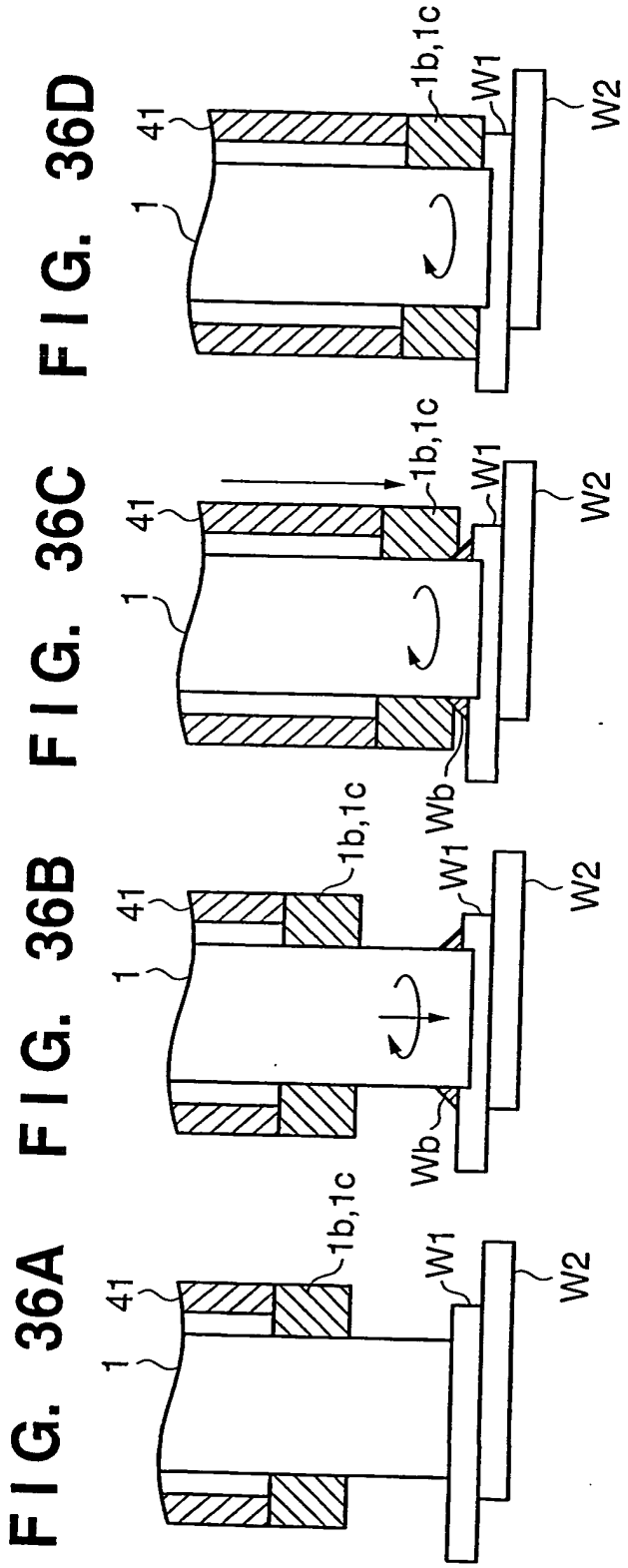
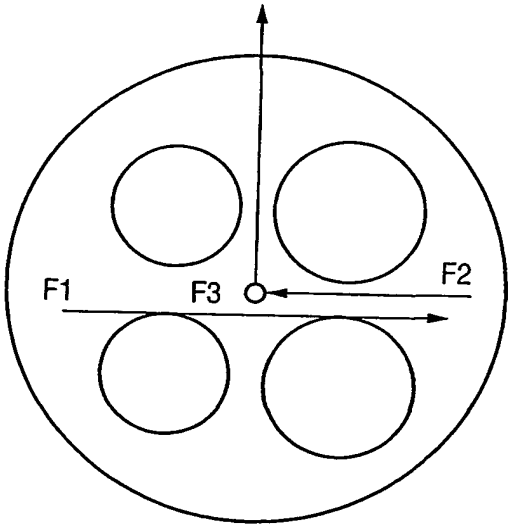


FIG. 36A FIG. 36B FIG. 36C FIG. 36D

FIG. 37

CODE	CHEMICAL COMPONENT (% BY WEIGHT)							
	Cu	Si	Mg	Zn	Fe	Mn	Ti	Al
AC4D	1.0~1.5	4.5~5.5	0.4~0.6	≦0.3	≦0.6	≦0.5	≦0.2	REST

FIG. 38



INTERNATIONAL SEARCH REPORT

Int[redacted]nal Application No
PCT/JP 01/03398

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B23K20/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB 1 385 473 A (LUC PENELOPE JANE VESEY) 26 February 1975 (1975-02-26) page 1, line 10 - line 13 page 1, line 32 - line 51 page 1, line 91 -page 2, line 4 page 5, line 55 - line 82 figures 1,2	1,2,4,6, 7,10 5,8
X Y	US 4 144 110 A (LUC JANE) 13 March 1979 (1979-03-13) column 1, line 6 - line 19 column 13, line 47 - line 55 column 14, line 11 - line 39 column 15, line 67 -column 16, line 22	1,2,10 5,8

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 June 2001	25/06/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Haegeman, M

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INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/JP 01/03398

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	DE 197 46 812 A (HENTSCHEL HOLGER DIPL ING ;SCHAAF ANDREAS DIPL ING (DE); SUTHOFF B) 29 April 1999 (1999-04-29) the whole document	1,6,10
X	DE 197 31 638 A (SCHAAF ANDREAS) 28 January 1999 (1999-01-28) column 1, line 36 - line 45 column 2, line 26 - line 31 claims; figures	1,9,10
X	EP 0 893 189 A (HITACHI LTD) 27 January 1999 (1999-01-27) figures 8,18 column 10, line 30 - line 46 column 12, line 20 -column 13, line 5	1,9,10

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/JP 01/03398

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